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ENGINEERING:

An Illustrated Weekly Journal.

EDITED BY WILLIAM H. MAW AND B. ALFRED RAWORTH.

OFFICES FOR ADVERTISEMENTS AND PUBLICATION, 35 & 36, BEDFORD STREET, STRAND, LONDON, W.C.

VOL. CI.—No. 2611.] *LONDON: FRIDAY, JANUARY 14, 1916.* [*Registered at the General Post Office as a Newspaper.*] [PRICE...6d. BY INLAND POST..8d.

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THE AGENT-GENERAL FOR VICTORIA, AUSTRALIA, invites

Tenders for the Supply and DELIVERY, at the Port of Melbourne, fully inclusive of Australian Customs Duties, &c., of the following:—

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Specifications, Conditions of Contract, and Forms of Tender, may be obtained by *bona fide* Tenderers on application at the Offices of the Consulting Engineers, JOHN COATES & COMPANY, *Ltd.*, 115, Victoria Street, London, S.W.

Tenders, accompanied by the preliminary deposit named in the Conditions of Tendering, must be delivered to the Agent-General for Victoria, Melbourne Place, Strand, W.C., not later than Eleven a.m. on Wednesday, 2nd February, 1916, marked "Tender for Fuse Distribution Boxes and Fuses—Contract 26,111."

The Government of Victoria does not bind itself to accept the lowest or any Tender. D 366

PETER McBRIDE,
Agent-General for Victoria.

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By Order,
C. W. YOUNG,
Nicholas Lane, London, E.C. Secretary.
13th January, 1916. D 374

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Secretary Wanted, by The Clyde Shipbuilding & Engineering Company, Limited, Port Glasgow; must be well acquainted with shipbuilding business, and fully qualified for the position. To the proper person a good salary will be given.—Apply (in confidence) to ALFRED TONGUE AND CO., 34, West George Street, Glasgow. D 332

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PLAISTOW FEVER HOSPITAL.

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Applications for the Post of ENGINEER at their Fever Hospital, Samson Street, Plaistow.

Applicants must not be of military age.

Salary £150 per annum.

The person appointed will be required to devote his whole time to the service of the Council, and will have charge of all boilers, plant, machinery and fittings, &c., and must keep in repair and good running order various motor vehicles used for the purposes of the Hospital.

Further and fuller particulars as to duties may be obtained, together with an Application Form, at my Office at the Town Hall, West Ham.

Applications, enclosed in the envelope provided, must be delivered to me not later than Noon, Wednesday, the 19th January, 1916.

Canvassing members of the Council is prohibited, and will disqualify for the appointment.

By Order of the Council,
GEO. E. HILLEARY,
Town Clerk.

Town Hall, West Ham.
3rd January, 1916. D 299

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The Guardians

Require an Engineer for their Workhouse, Infirmary and Childrens' Homes at Homerton, N.E. Candidates must be thoroughly competent to take charge of the Boilers, Economiser, Engines, Machinery, Deep Well Pumps, Hot and Cold Water and Steam Apparatus, Refrigerator, Electric and Hydraulic Lifts, Electric Lighting Installation and other Electrical Fittings (including X Ray and other Electro-Medical Treatment Apparatus) and to supervise the execution of all necessary Engineering, Pipe Fitting and General Repairs, and generally to be responsible for the working of his Department (subject to the Master of the Workhouse), and the satisfactory condition of all Engineering and Sanitary Work in the Establishments. Salary £3 per week, together with house free of rates and taxes, and supplied with gas, coals and water (overalls will be provided for their use of the Engineer, but the same will remain the property of the Guardians).—Application Forms to be obtained of the CLERK TO THE GUARDIANS, Hackney Union, 2, Sidney Road, Homerton, N.E. D 365

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Engineer Wanted, at Once, with or without capital, to join an established manufacturing business. Must be experienced and capable of controlling automatic plant on repetition work.—Write fully, to ENGINEER, care of E. T. BROWN, Lichfield Street, Wolverhampton. D 362

Temporary Assistant Engineer WANTED, immediately, by the Port of London Authority. Applicants must have passed the examination for Associate Membership of the Institution of Civil Engineers, and had experience in railway, dock and harbour works, or with public works contractors. Preference will be given to men ineligible for military service.

Applications must be on the prescribed Form, obtainable at the Office of the CHIEF ENGINEER, 100, Leadenhall Street, London, E.C., and must be delivered at that Office, accompanied by copies of not more than three recent testimonials, not later than Ten a.m. on Tuesday, 18th January, 1916. D 273

Civil Engineering Assistants and DRAUGHTSMEN REQUIRED in drawing office of Government Department (London), in connection with war services. Those accustomed to steel construction work and calculations preferred. Salary at the rate of £100 to £150 per annum according to qualifications.

Candidates eligible for military service or employed on Government work will not be considered.

State age, experience and enclose copies of recent testimonials to BOX No. 482, care of STREET'S, 8, Serle Street, London, W.C. D 368

Technical Chemist or Chemical ENGINEER REQUIRED. Must have had experience in the production of alumina from bauxite.—Address, giving full particulars, D 356, Offices of ENGINEERING.

Engineer-Draughtsman REQUIRES POSITION, experienced marine, Diesel and steam, and auxiliaries and aero engines; shop experience, able to commence at once.—Address, D 354, Offices of ENGINEERING.

Technical Assistant Required by a Firm of Chartered Patent Agents in London. Preference given to one who has passed the qualifying examination.—Reply, stating age, qualifications, experience, and salary required, to 2345, SELL'S Advertising Offices, Fleet St., E.C. D 350

Wanted, for Government work, in Derby, CHIEF TOOL DRAUGHTSMAN, experienced in milling and drilling jigs, and press-tool work. It is essential that applicants should have had experience in the manufacture of small accurate parts.—Apply, stating age, experience, salary expected, and a reference, to the nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this paper and No. A 370. D 341

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Draughtsmen, Several Senior and Junior, REQUIRED immediately, for large constructional and general engineering works in the Midlands. Controlled establishment on Munitions work. State age, experience, and salary required. No one employed on Government work will be engaged.—Apply to your nearest LABOUR EXCHANGE, mentioning this paper and D 371.

Wanted, for Government work, in Derby, several ASSISTANT TOOL DRAUGHTSMEN; experience in milling jigs, drilling jigs, or Cleveland automatics essential. Applicants should have had good technical training, and preferably experience in the shops. No man on Government work need apply.—Apply, stating age, experience, salary expected, and a reference, to the nearest BOARD OF TRADE LABOUR EXCHANGE, mentioning this paper and No. A 371. D 342

Draughtsman, Leading, Constructional and Mechanical.—If within 10 miles Acton, and not on Government work, state age, salary, experience, and copies of reference, to D 330, Offices of ENGINEERING.

Draughtsmen, Experienced, WANTED, for engineering works, North-East Coast District. Those having experience in marine or turbine work preferred. No person already employed on Government work will be engaged.—Apply, nearest LABOUR EXCHANGE, mentioning this Journal, and D 299.

Draughtsmen (Improvers), WANTED, in London drawing-office of a Public Department in connection with war services. Salary at the rate of about £80 per annum.

Candidates eligible for military service or employed on Government work will not be considered.

State age, experience, and enclose copies of recent testimonials, to BOX No. 483, care of STREET'S, 8, Serle Street, London, W.C. D 369

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Engineer, Mechanical and Electrical, with extensive experience technical and commercial, capable manager, OPEN to ENGAGEMENT.—Address, D 340, Offices of ENGINEERING.

Experienced Foundry Manager SEEKS RE-ENGAGEMENT. Good references.—Address, D 345, Offices of ENGINEERING.

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STABLE BIPLANE ARRANGEMENTS.*

By JEROME C. HUNSAKER, S.M., Member of the American Society of Naval Architects and Marine Engineers; Assistant Naval Constructor, United States Navy.

(*Concluded from page* 3.)

5. *Lift and Drift; Units; Density; Velocity; Precision.*—In Figs. 12 and 13, subjoined, are plotted the lift coefficients for the various models. The lift coefficient is defined to be $K_y = \frac{L}{A V^2}$, where L is the observed lift in pounds; A, area of model in square feet; and V, wind velocity in miles per hour. Similarly, the drift coefficients are plotted in Figs. 14 and 15, where $K_x = \frac{D}{A V^2}$ in the same units as above. These coefficients vary as the density of the air, and are referred to air of density 0.07608 lb. per cub. ft.

The ratio of lift to drift is a measure of the effectiveness of a wing. This quotient is sometimes called "efficiency." Curves are given for comparison in Figs. 16 and 17, on page 26. The wind speed was kept at 30 miles per hour for all tests.

Individual measurements of force, moment, angle, wind velocity, &c., are believed from previous calibration tests to be precise within 1 per cent. Calculated coefficients, vector co-ordinates, centres of pressure, &c., in which all measurements have been combined, should be precise within 3 per cent.

6. *Biplane Interference Losses.* Monoplane *versus* Biplane No. 1. A single wing, 18-in. span by 3-in. chord, with square wing-tips, was first tested for comparison with results obtained at the National Physical Laboratory, England, for a similar model made to the same wing section, R A F 6.† The measurements are found to agree within the probable experimental errors. To determine the extent of losses due to biplane interference, an orthogonal biplane was next tested. It was made up of two wings identical with the above, chords parallel, and spaced with a gap between them equal to the chord. This biplane is designated as Biplane No. 1.

The resultant forces for the biplane are shown in Fig. 2, on page 2 *ante*, and centre of pressure in Fig. 10. It appears from the latter that the centre-of-pressure motion, and hence the degree of longitudinal instability, is practically the same for the two cases. This is of interest in that it demonstrates the correctness of an assumption commonly made.

The lift curves of Fig. 12 show a pronounced loss in lift from the monoplane to the biplane (No. 1). The loss in maximum lift is about 10 per cent. The burble-point comes at 14 deg. for both, and the curves are of the same general character. The drift curves of Fig. 14 are not greatly different, the biplane drift being somewhat less at small angles. The biplane and monoplane are best compared on a basis of equal lift rather than on angle of incidence of chord to wind.

The general summary sheet, Fig. 18, on page 26, gives lift-drift ratio plotted on lift coefficient as abscissæ. Curves for the monoplane and biplane No. 1 show a slight difference for values of lift coefficient below 0.0007, indicating that for high speeds the biplane is better than the monoplane. However, at all other values corresponding to high lift coefficient and low aeroplane speed in practice, the biplane is considerably less effective.

Lift-drift ratio for the biplane is given in the annexed Table I. as a per cent. of the corresponding lift-drift ratio for the monoplane. For any point K_y is constant for monoplane and biplane, and a percentage decrease in lift-drift indicates the same percentage increase in K_x or drift, and *vice versâ*.

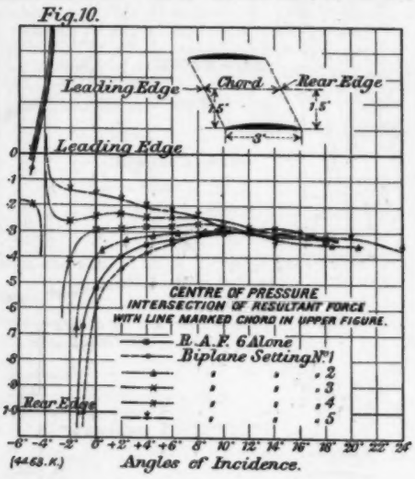
TABLE I.—*Lift-Drift Ratio for Biplane given as Percentage of Lift-Drift Ratio of Monoplane.*

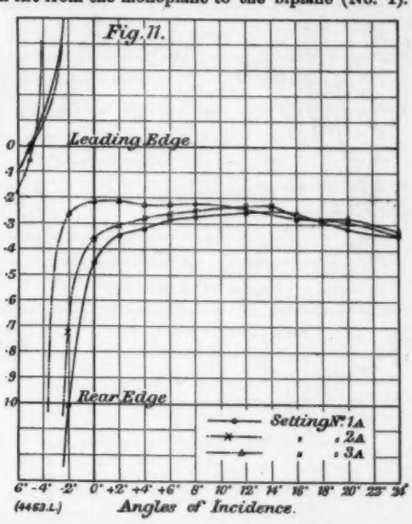
K_y	$\frac{K_y}{K_x}$	K_x Biplane.
0.0004	110	90
0.0006	107	93
0.0008	99	101
0.0012	85	115
0.0016	85	115
0.0020	75	125
0.0024	73	127

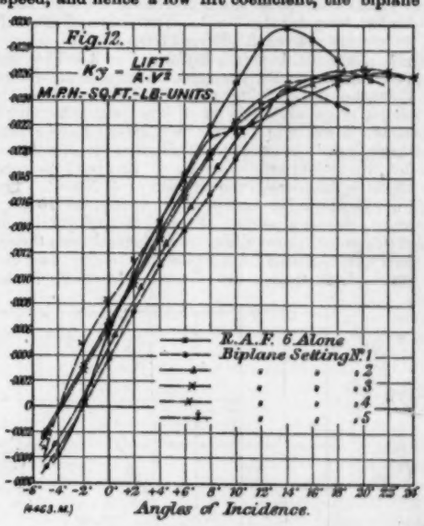
This table shows clearly the advantage of the biplane arrangement for a high-speed scout, such as the British "Tabloids." At a high aeroplane speed, and hence a low lift coefficient, the biplane resistance is 10 per cent. less than the monoplane resistance. This is an appreciable saving. For a machine which must fly slow, and consequently with a high lift coefficient, the biplane resistance is from 15 to 25 per cent. greater than the monoplane resistance.

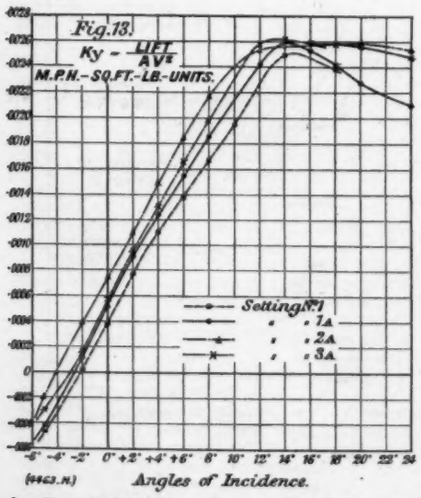
7. *Stagger, 50 per Cent. Biplane No. 2.*—Biplane arrangement No. 2 is the same as the orthogonal biplane No. 1, except that the upper wing is placed ahead of the lower by an amount equal to 50 per cent. of the chord. This is defined to be a "stagger" forward of 50 per cent.

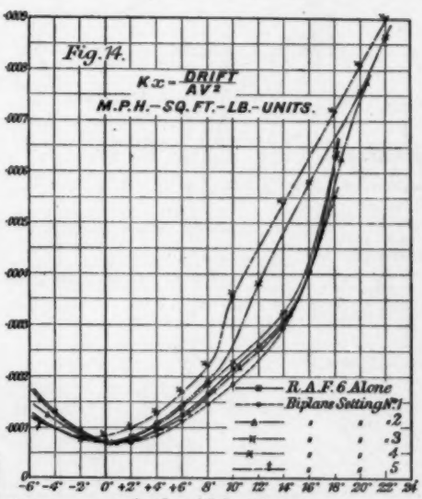
Fig. 3, on page 2 *ante*, shows that the resultant forces from 2½ deg. to 10½ deg. intersect near a single point. If this point be the centre of gravity of an aeroplane, there will be no pitching moment

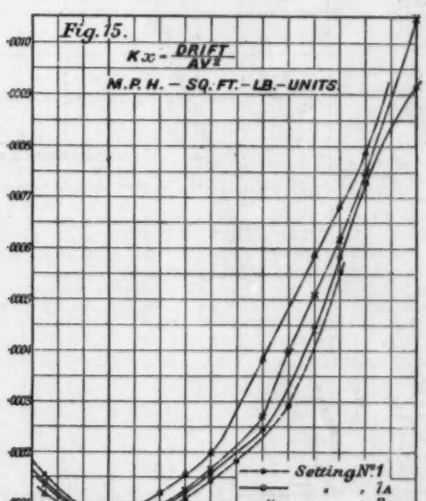












* An account of a research conducted at the wind tunnel of the Massachusetts Institute of Technology.

† Technical Report of the Advisory Committee for Aeronautics, 1912-13, page 90.

throughout this range of angle. The machine will be neutral as regards its equilibrium. For the extreme range of flying angles from 1½ deg. to 20½ deg. the equilibrium is stable.

A pilot who flew such a machine undoubtedly would pronounce it stable, since he would be unlikely to risk a steep dive, bringing the incidence into negative angles. However, this wing arrangement, though excellent in other respects, is unstable for the range of angles + ½ deg. to −4½ deg. A sudden dive tends to become steeper, or, as the French put it, to become *engagé*. It might be possible to prevent this in a design by use of a small tail surface.

The centre-of-pressure curve of Fig. 10 is more nearly flat than the orthogonal biplane No. 1, as would be expected. The lift curve of Fig. 12 shows a later burble-point and a maximum lift 6 per cent. higher than for the No. 1. The drift and lift-drift curves are not much different from No. 1.

8. *Decalage* 1 *Deg. Biplane No.* 3.—The test was repeated with the same arrangement, except that the upper wing was tilted up so that its chord made an angle of 1 deg. with the chord of the lower wing. This is a divergence or plus "decalage" of 1 deg. This new arrangement, No. 3, is shown by Fig. 4, on page 2 *ante*, to have improved the stability of No. 2. The force vectors for angles from 0 deg. to 10 deg. intersect near a point. If the centre of gravity be at this point, the equilibrium is neutral from 0 deg. to 10 deg., stable from 10 deg. to 18 deg., and unstable from 0 deg. to −5 deg. However, if the centre of gravity be placed low, at about the intersection of the vector for 4 deg. and the lower chord, the equilibrium is stable for all the range from − 2 deg. to + 18 deg. The unstable region is for angles well below − 2 deg.

The centre-of-pressure curve, Fig. 10, is flat for all angles above 0 deg. The maximum lift is about 3 per cent. greater than for biplane No. 1. The lift curve in the neighbourhood of the burble-point is also somewhat more flat. The maximum lift-drift ratio is about the same as for biplane No. 1.

9. *Decalage*, 2½ *deg.*; *Stagger*, 50 *per Cent.*—*Biplane No.* 4.—The effect of decalage on longitudinal stability was investigated further by giving the previous arrangement a decalage of 2½ deg.

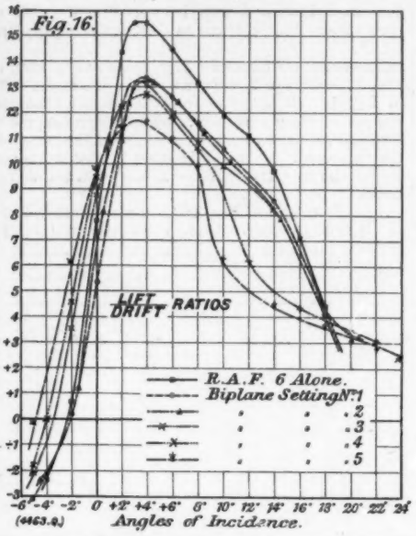
The result appears to be a happy one. The vectors of Fig. 5, on page 2 *ante*, show that for a centre of gravity located anywhere in the lower triangle, bounded by the vectors for −2 deg. and −5 deg., the equilibrium is stable longitudinally throughout the entire range of pitching angles, −5 deg. to +20 deg.

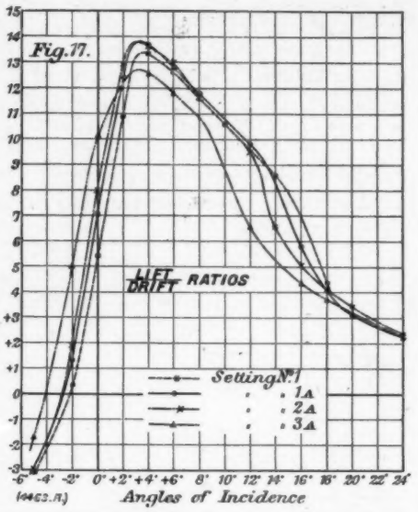
Fig. 10 shows that, whereas the centre-of-pressure curve turns to the rear for small negative angles on the monoplane, biplane No. 1, biplane No. 2, and biplane No. 3, the contrary holds for the present arrangement. Thus for negative angles below − 3 deg., the centre of pressure curve turns forward.

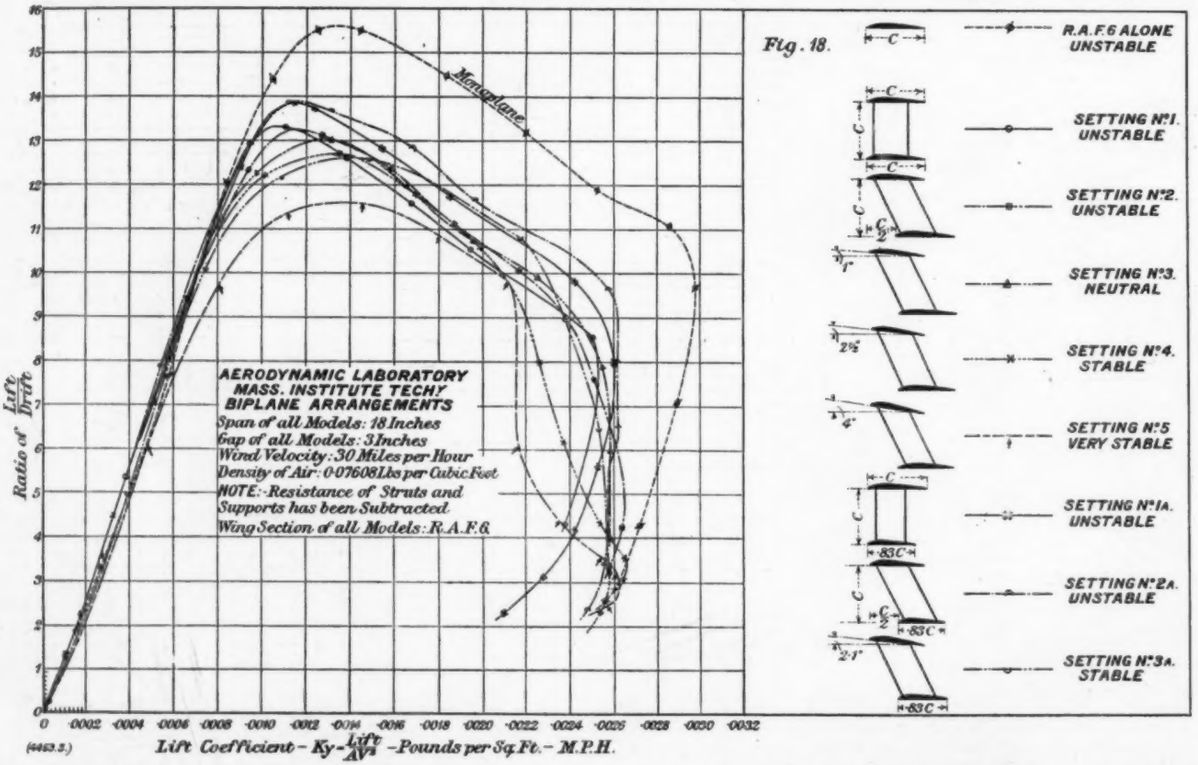
The degree of stability given by biplane No. 4 is greater the lower the centre of gravity, on account of the diverging nature of the resultant force vectors. Compared with biplane No. 1, there is a gain of 3 per cent. in maximum lift, with a loss of 5 per cent. in maximum lift-drift ratio. At the small values of lift coefficient corresponding to high aeroplane speeds, biplanes Nos. 1 and 4 give the same resistance (see Fig. 18, above).

In conclusion, then, biplane No. 4 is completely stable, and at the same time practically equivalent to orthogonal biplane No. 1.

10. *Decalage*, 4 *deg.*; *Stagger*, 50 *per Cent. Biplane No.* 5.—In case it be desired to build a very stable machine for amateurs or for training beginners in aviation, the decalage may be increased to 4 deg.—biplane No. 5. The force vectors of Fig. 6, page 2 *ante*, show complete stability for any centre of-






Monoplane
AERODYNAMIC LABORATORY
MASS. INSTITUTE TECHY
BIPLANE ARRANGEMENTS
Span of all Models: 18 Inches
Gap of all Models: 3 Inches
Wind Velocity: 30 Miles per Hour
Density of Air: 0·07608 Lbs per Cubic Foot
NOTE:-Resistance of Struts and
Supports has been Subtracted
Wing Section of all Models: R.A.F.6.
Ratio of Lift/Drift
(4463.3.)
Lift Coefficient - Ky - Lift/AV² - Pounds per Sq. Ft. - M.P.H.

No. 5. The lift curve of Fig. 12 shows a later burble-point and a maximum lift 13 per cent. less than for biplane No. 1. The lift curve near the burble-point is not sharp, and hence this very stable arrangement could not easily be stalled by an inexperienced pilot. For a school machine this is especially important. A peculiar point (of theoretical interest only) is that the lift curve (Fig. 13) has two burble-points, probably due to the fact that the decalage of the upper wing brings that wing up to its angle of maximum lift before the lift of the lower wing reaches its maximum.

11. *Lower Chord*, 83 *per Cent. of Upper. Bi-*

This degree of stability is considered to be excessive, but the circumstances which would justify its use probably would not concern great speed or minimum wing area. The maximum lift is not different from that of the other biplanes. The

plane 1A.—It has been shown by M. Eiffel* that the loss of lift of an orthogonal biplane is due in large part to the lower wing. The eddy formed on top of the lower wing is interfered with by the upper wing. The result is that the lower wing lifts much less than the upper. It would seem logical then to expect that if we cut down the area of the lower wing we should reduce this loss.

A model was constructed having a lower wing chord 83 per cent. of the upper wing chord. As an orthogonal biplane, represented as biplane No. 1A in Fig. 7, on page 2 *ante*, the resultant force vectors indicate longitudinal instability of the same nature as that of biplane No. 1. The centre-of-pressure curve, as given in Fig. 10, is of the same general character as that for biplane No. 1.

The maximum lift, Fig. 13, is 4 per cent. higher, the maximum lift drift, Fig. 17, about 4½ per cent. higher than for biplane No. 1. For high speeds when a low lift coefficient is used, biplanes No. 1 and No. 1A are equivalent. For low speeds or high angles of incidence, implying a high lift coefficient, the drift of No. 1A is more than 8 per cent. less than for No. 1 (see Fig. 18).

monoplane R A F 6 was applied as a percentage to the published results on the modified R A F 6.

It appears that for the reversed-curve wings the maximum lift is 17 per cent. less, and the maximum lift-drift ratio 14 per cent. less, than for our biplane No. 1. This is a serious price to pay for stability. However, for very low values of lift coefficient the reversed-curve biplane offers over 20 per cent. less resistance. For a racing machine, when a high landing speed may be tolerated, this type of wing might be employed with advantage. For general purposes, the loss of maximum lift is too serious to be outweighed by its low drift at great speeds.

15. *Conclusions.*—The relative merits of the various wing combinations are brought out in the subjoined Table II. Coefficients are there expressed in terms of the coefficients for the orthogonal biplane (No. 1) taken as unity. It is to be noted that the stability of biplane No. 4 is gained at the expense of but 4 per cent. of maximum lift-drift ratio, while a gain is obtained in all other properties.

Biplane No. 3A is stable, and likewise loses but

TABLE II.—CHIEF PARTICULARS OF MODELS TESTED.

Designation.	Monoplane.	Biplane No. 1.	Biplane No. 2.	Biplane No. 3.	Biplane No. 4.	Biplane No. 5.	Biplane No. 1A.	Biplane No. 2A.	Biplane No. 3A.	Reverse Curve Wings.
Gap	—	C	C	C	C	C	C	C	C	C
Stagger	—	0	0.50 C	0.50 C	0.50 C	0.50 C	0	0.50 C	0.50 C	0
Upper chord	C	C	C	C	C	C	C	C	C	C
Lower chord	C	C	C	C	C	C	0.83 C	0.83 C	0.83 C	C
Decalage deg.	—	0.0	0.0	1.0	2.5	4.0	0.0	0.0	2.1	0.0
Max. $\frac{k_y}{k_x}$	1.15	1.00	1.00	0.95	0.95	0.87	1.04	1.04	0.96	0.86
Max. k_y	1.16	1.00	1.06	1.03	1.03	1.04	1.04	1.04	1.03	0.83
$\frac{k_y}{k_x}$ where $k_y = 0.0005$	0.90	1.00	1.00	1.00	1.00	0.90	0.09	1.03	0.96	1.21
$\frac{k_y}{k_x}$ where $k_y = 0.0018$	1.24	1.00	1.02	1.01	1.02	0.99	1.05	1.08	1.05	0.88
Range of flat burble-point in degrees	2	2	2	6	4	4	4	12	12	2
Remarks	U	U	U	N	S	S	U	U	S	S

S = stable. N = neutral. U = unstable. C = chord length (upper.)

12. *Lower Chord, 83 per Cent.; Stagger, 50 per Cent. Biplane* 2A.—The test was repeated with the same model having the upper wing staggered forward by 50 per cent. of its own chord. No marked change in the properties of the biplane No. 1A are to be noted, except a very pronounced flattening of the lift curve near the burble-point (see Fig. 13). This is a considerable advantage. The flat range is from 12 deg. to 24 deg. A machine with such wings would not easily stall if the pilot were thrown up to an angle greater than the angle of maximum lift.

13. *Lower Chord, 83 per Cent.; Stagger, 50 per Cent. Decalage, 2.1 deg. Biplane* 3A.—Reference to Fig. 9, on page 3 *ante*, shows that the force vectors for this biplane give longitudinal stability for any centre of gravity located within the lower triangle formed by the vectors for − 2 deg. and − 5 deg. This will be the case for a heavy sea-plane. A high centre of gravity will show instability for negative angles of incidence. The centre-of-pressure curve (Fig. 11) is misleading, as was pointed out above, since it is given by intersections with a plane midway between the wings. The centre of gravity must be lower than this to give stability. The lift curve of Fig. 13 shows a maximum lift equal to that of biplanes Nos. 1A and 2A, and a burble-point even more flat than biplane No. 2A. The flat lift curve near the burble-point is the principal merit of biplane No. 3A. The maximum lift of No. 3A is about the same as that of No. 3, a similar arrangement with equal wing chords top and bottom. For low values of lift coefficient No. 3A is not quite so good as No. 3; for high values of lift coefficient No. 3A is slightly superior.

The biplane No. 3A appears to unite a fair degree of longitudinal stability with a very flat burble-point. The other properties of the wing are not greatly altered.

14. *Reverse Curvature.*—A wing whose section shows a reverse curve near the trailing edge is well known to be longitudinally stable. Tests at the National Physical Laboratory, England, give the properties of the R A F 6 so modified in comparison with the original section. These test results apply only to a monoplane. The biplane effect found by us from tests on biplane No. 1 and 4 per cent. on maximum lift-drift ratio. This arrangement, moreover, has a lift curve which remains at its maximum over a range of 12 deg.

If longitudinal stability be assured by a tail, biplane No. 2A is the most effective arrangement. It is superior by from 4 to 8 per cent. in all aerodynamic properties to biplane No. 1. Furthermore, it has a lift curve which remains flat for a range of 12 deg. over the burble-point, while this range is but 2 deg. for biplane No. 1.

It is believed that the present investigation should permit a designer by interpolation to form an estimate of the characteristics of other combinations than those here tested, at least with sufficient precision to satisfy him that no fantastic results are to be expected, and that, as in all engineering work, his problem is a compromise. Excellence in one characteristic is likely to involve some sacrifice in others.

* "Nouvelles Experiences sur la Resistance de l'Air." G. Eiffel. Dunod et Pinat; Paris, 1914.

PURE ELECTROLYTIC IRON AND BORON.

THE suggestion of electrolytic iron for technical purposes crops up again from time to time, and it is not so hopeless as it may appear. Electrolytic iron may well be made in quantities to justify its use for armature cores, transformer sheets, &c. The pure electrolytic iron which Tryge D. Yensen prepared in the engineering experiment station of the University of Illinois, in 1914, proved magnetically superior to all other iron; but it had, of course, a very low electric resistance, and it still contained a little oxygen—about 0.3 per cent., possibly as iron oxide—in addition to at least 0.006 per cent. of carbon and 0.1 per cent. of silicon. To investigate the properties of this iron, it was melted in magnesia crucibles, holding about 500 grammes (1 lb.) of the iron, in an Arsem vacuum furnace, the pressure in the furnace being reduced to 2 mm. or 5 mm. of mercury; a further evacuation is being tried with continued experiments. The molten iron was then forged into ½-in. rods, from which other test-pieces were prepared. The cooling curves of this iron were between 900 deg. and 200 deg. Cent., straight lines; the cooling was accomplished in 24 or 48 hours. The permeability was 19,000 at a flux density of 9500 gauss, and the average hysteresis loss was less than half that of the best transformer iron; the specific electric resistance was 9.96 microhms, but could be raised by the addition of aluminium or silicon. When melted in an atmosphere of carbon monoxide under atmospheric pressure, this iron absorbed both carbon and oxygen, and thus became magnetically inferior. When fused with carbon, the resulting iron was found to contain less carbon than had been added; and, indeed, iron containing as much as 0.5 per cent. of carbon, when melted *in vacuo*, would lose from 50 to 90 per cent. of this carbon, evidently because the oxygen in the iron combined with the carbon.

It occurred to Yensen to remove the oxygen contained in the electrolytic iron by some agent which would not, like carbon, deteriorate the iron magnetically. In these experiments boron, having a very beneficial effect on copper castings when used as a deoxidiser, was tried as a reducing agent. The results of the researches just noticed, and of the experiments with boron, are described in Bulletins Nos. 74 and 77 of the University of Illinois. Although boron is chemically and physically a very interesting and peculiar element, the boron alloys have not received the attention which they seem to deserve, considering the similarity of boron to carbon and silicon. The latest research in this field, published by G. Hannesen in the *Zeitschrift für Anorganische Chemie* in November, 1914, started from ferro-boron of Goldschmidt and Krupp iron. At Urbana, Illinois, boron was used by Yensen in the form of the boron suboxide of Weintraub, which is essentially B_7O, and of the boron suboxide flux, also prepared by Weintraub, which contains about 8 per cent. of B_2O and, further, magnesium borate and boric anhydride. The boron suboxide was added to the iron (which was melted *in vacuo*) in very small increments of 0.01 per cent., since it was soon noticed that the effect on the iron of very small proportions of boron was totally different from that of appreciable amounts of boron.

As regards the chemical reactions, boron was found to behave somewhat like carbon, but not quite like it. Even small proportions of boron had a double effect, part of the boron combining with the oxygen in the iron, and part alloying with the iron, whilst carbon did not alloy with the iron until the deoxidation of the iron oxide was practically complete. A complete reduction of all the iron oxide in the iron could not be obtained with the aid of boron, and the effects of the boron which was taken up by the iron were beneficial only for very small percentages of boron. As long as the percentage of boron suboxide did not exceed 0.05, the magnetic properties were slightly improved; but when the contents of B_2O exceeded 0.1 per cent., the effect was detrimental. Thus the curves of retentivity, coercive force, and hysteresis first showed a rapid fall to a small minimum, followed at once by a steady rise, whilst the permeability curves first showed a slight rise, followed by a decided descent as the boron percentage was increased. The electric resistance curve hardly brought out this difference; the addition of boron seemed to increase the resistance slightly from the very first, by about 0.62 microhm per 0.1 per cent. of boron combined with iron. Most of the mechanical properties were similarly affected; the ultimate strength and stress at yield-point were raised. In the elongation, which decreased on the addition of boron, and also in the reduction of area, which likewise decreased, the difference between the effects of the first very small percentage of boron and appreciable proportions was again more marked. Practically one may thus say that a very little boron improves iron magnetically, whilst appreciable quantities of boron deteriorate these properties, and that otherwise boron influences iron very much after the manner of carbon. If the boron-iron is, as it appears, little superior to Swedish charcoal-iron, the magnetic study of these alloys would not have much practical value.

THE SWEDISH STATE AND FURTHER WATER-POWER EXPLOITATION.—It has been stated that the Swedish State, in connection with further electrification of State railways, is contemplating the purchase of the Kranzede Falls. The capacity of these falls is calculated at 64,000 horse-power, and after certain regulations have been completed, at 155,000 horse-power.

THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE.—A course of ten lectures on "Professional Organisation" will be given at the London School of Economics and Political Science (University of London), Clare Market, Kingsway, W.C., by Mrs. Sidney Webb, D.Litt., and Mr. F. H. Hayward, D.Litt., M.A., B.Sc., at 6 p.m., on Mondays, beginning on the 17th inst. The fee for the course is 12s. 6d.

ELECTRIFICATION OF THE MANCHESTER TO BURY SECTION OF THE LANCASHIRE AND YORKSHIRE RAILWAY.

We have received from Mr. John A. F. Aspinall, M. Inst. C.E., General Manager of the Lancashire and Yorkshire Railway, the following account of the electrification of the Manchester to Bury Section of that railway :—

The improvements made from time to time by the Lancashire and Yorkshire Railway in the work of conveying passengers quickly and comfortably have been most marked, and about eighteen months ago the directors of the Lancashire and Yorkshire Railway Company, acting on the advice of Mr. J. A. F. Aspinall, the general manager, determined upon the electrification of that important section of the company's lines extending from Manchester to Bury, and passing through the favourite residential suburbs of Heaton Park and Prestwich. A map of this district is shown in Fig. 1, on this page.

The Lancashire and Yorkshire Railway Company first adopted electrical working on the section between Liverpool and Southport in 1904, and the highly satisfactory results obtained have induced the company to apply electric traction with complete confidence on what is familiarly known as the Prestwich Branch. Experience has proved that electrification of suburban railways encourages the growth of traffic, and has the additional advantages of increasing the capacity of the line and of terminal stations. This is the first railway in the Manchester district to be converted to electric traction, and the inauguration of such a service marks an improved stage in the economic development of the city, and the evolution of rapid transit between the city and its suburbs. This district being the second portion of the company's system to be electrified, derives the benefit of eleven years' experience gained on the Liverpool and Southport line.

The live-rail direct-current system, as used on the Liverpool and Southport line, is still adhered to, but the voltage has been raised from 600 to 1200. The railway company have been led to adopt this higher voltage due to the satisfactory results gained on their electrified line between Bury and Holcombe Brook, where direct current is used at 3500 volts, but with overhead construction.

The growing importance of North Manchester as a healthy residential district, and the ever-increasing number of people who are making their homes there, induces the belief that the new undertaking will be as conspicuously successful as its forerunner, which now affords means of rapid transit for thousands of people between their homes on the Southport line and the City of Liverpool, where they have the fastest suburban service in the world.

Great as have been the improvements in recent years for reaching the inner suburbs of Manchester, the need for improved travelling facilities to the outer suburbs had not been fully met. The time occupied in travelling is often the measure of the distance at which the city worker can live away from his place of business, and this with the usual methods of transit means that he must live within a radius of three miles. When the full service of electric trains is established on the North Manchester suburban line, the residential area will be increased, because the augmented and accelerated service will bring the outlying districts virtually nearer than they are to-day.

Prestwich, for example, is five minutes nearer to Manchester Town Hall than it has been hitherto. The district served by the new electrification scheme, standing as it does at an average height of 300 ft. above the sea-level, is becoming increasingly popular for residential purposes. The purchase of Heaton Park by the City Corporation, and the town-planning schemes which are in hand, have greatly encouraged and extended building operations in that district.

The electrification was commenced before the outbreak of war, and as the necessity was felt for a rapid and efficient train service, and considering that, at that time, appreciable progress had been made, and all tenders placed, it was decided that the work should be completed at the earliest possible moment.

The scheme has been carried out under the general direction of Mr. J. A. F. Aspinall, the general manager of the railway company, by his chief mechanical engineer, Mr. George Hughes, and his chief civil engineer, Mr. D. C. Rattray. All plans and specifications were prepared, and contracts for all plant placed, by the C. M. E. staff at Horwich, in addition to which a preponderance of the detail work, both in connection with the drawings and manufacture of material have been carried out at the company's locomotive works at Horwich. The civil engineering portion was dealt with by the C. C. E. department at Hunt's Bank, Manchester. Although the progress has been considerably delayed, due to the present crisis, it is anticipated that the line will be opened for passenger traffic early in the year in which we are now entering.

The length of the line which is now being converted represents 22 miles of single track, but as this is only the first stage of an important electrification scheme for the Manchester area, it was decided to provide a new power-station of sufficient capacity in the first instance to serve the needs of present requirements, and provide for considerable future extensions. In consequence of the war, the full service of electric trains will not be put into force immediately, but 27 per cent. of the existing steam trains will be replaced by electric trains, and further electric trains will be added which will augment the present service by 25 per cent. When the full electric service is established there will be 90 trains in each direction per day. The trains will run every 20 minutes between 5.30 a.m. and 7.30 a.m. and 7.10 p.m. to 11.30 p.m., and from 7.30 a.m. to 7.10 p.m. there will be a 10-minute service to Radcliffe, with every other train running through to Bury, making a 20-minute service to the latter town during those hours.

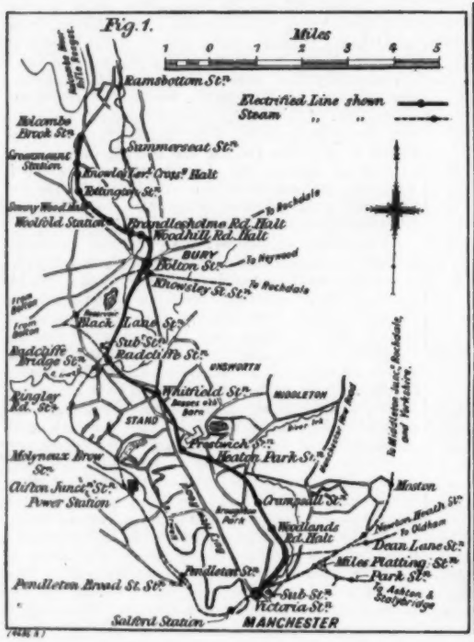


FIG. 1. MAP OF THE ROUTE.

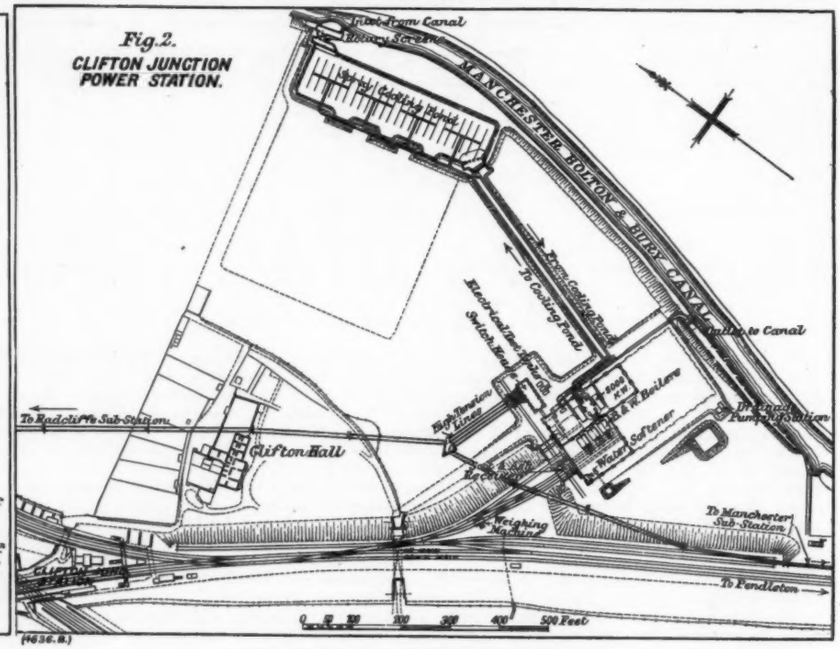


FIG. 2. KEY PLAN OF POWER-STATION.

The power-station under consideration has been built near Clifton Junction Station, a point 4¾ miles from Manchester, on the main line between Manchester and Bolton, a situation which fulfils all the above-mentioned conditions. It occupies a central position to the Lancashire section of the Lancashire and Yorkshire Railway, and is adjacent to extensive coal-fields. The foundations are everything that could be desired, and there is a good supply of water from the Manchester, Bury and Bolton Canal, which is owned by the railway company.

The ground level at the power-station is 37 ft. below the main line, which at this point is carried on an embankment, thus enabling coal-wagons to be run directly over the tops of the coal-bunkers. This arrangement makes use of what is obviously the best coal-conveyor—namely, the coal train running between the colliery and the power-station, thus obviating the necessity of installing coal-conveying appliances.

For the purpose of handling material between the two levels during the constructional period, and for subsequent use, a 50-ton electric overhead travelling crane, manufactured by Messrs. T. Broadbent and Sons, Limited, of Huddersfield, has been provided.

An inspection of the block plan of the power-station and its surroundings, Fig. 2, shows the general lay-out of the station with regard to the railway and the canal, together with the inlet and outlet connections of the canal for the supply of cooling-water. A spray cooling pond is also provided to supplement the natural cooling which takes place from the canal itself. The slight natural flow of water along the canal is in the direction of Manchester, and the cooling-water scheme makes use of this feature, the artificial cooling being brought into play when necessary.

The power-station structure (Figs. 3 and 4, on our two-page plate, and Fig. 5, on page 29) consists of a steel skeleton filled in with brick-work. The steel-work carries the crane runways, roof, economiser floor, complete with economisers, fans, and chimneys. The building is of a substantial design, in which the following objects have been kept in view :—

(a) Ample room around the various machinery.
(b) Accessibility for repairs and ease of inspection.
(c) Abundance of light to all parts.
(d) The lay-out of the auxiliary machinery specially has been such as to keep everything in full view of the operating staff.

A general view of the turbine-room is shown in Fig. 8, and of the boiler-room in Fig. 9, page 32. The experience gained with other electrification schemes has shown that power-stations generally have not been designed with a sufficient provision for growth, which, in the majority of cases, has proceeded at a very rapid rate. At Clifton this contingency has been carefully provided for.

Boiler-Room (see Fig. 9).—The boiler-room is 110 ft. long and 90 ft. wide, and is parallel with the turbine-room. The boiler-room at present contains three Babcock and Wilcox water-tube boilers, each having a normal evaporation of 32,000 lb. of water per hour, from and at 212 deg. Fahr., the steam pressure being 200 lb. per sq. in. gauge, superheated to 700 deg. Fahr. at the outlet.

A glance at Fig. 4 will show that the boilers are arranged in pairs alongside each other; each pair makes up a steam unit, and is provided with its own induced-draught plant and chimney.

The boilers are fitted with chain-grate mechanical stokers of Babcock and Wilcox's latest type. They are driven by three-phase 440-volt motors, and fitted with a variable-speed gear-box, allowing a speed variation to the grate of from 6½ ft. to 25 ft. per hour. The grate area of each boiler is 144 sq. ft., the heating surface 7135 sq. ft., and the superheating surface is 2635 sq. ft. Green's economisers are used, and have been placed above the boilers. This position was found to be the most ad-

POWER-STATION.

In considering the question of the design and situation of the power-station at Clifton due regard has been paid to the four controlling factors in power-station location, namely :—

1. It should be as near as possible to the electrical centre of gravity of the anticipated supply.
2. It should have suitable subsoil for foundations.
3. There should be a good and ample supply of water.
4. Easy facilities for the supply of coal and removal of ashes.

ELECTRIFICATION OF THE MANCHESTER TO BURY SECTION; L. AND Y. RAILWAY.

(*For Description, see Page 28.*)

Fig. 5.

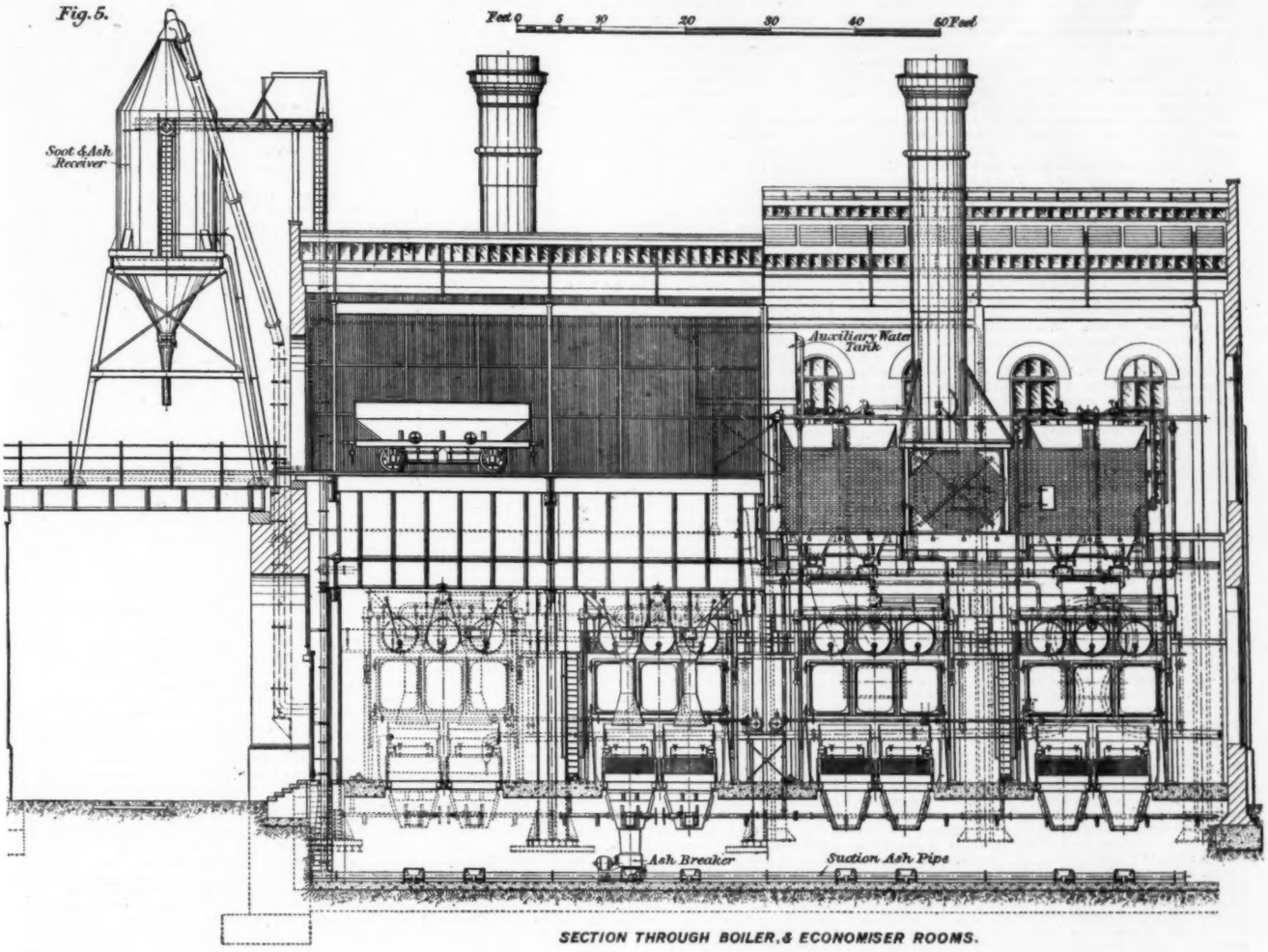

Feet 0 5 10 20 30 40 50 Feet
Soot & Ash Receiver
Auxiliary Water Tank
Ash Breaker
Suction Ash Pipe
SECTION THROUGH BOILER & ECONOMISER ROOMS.

FIG. 5.

FIG. 6. ASH-RECEIVER.

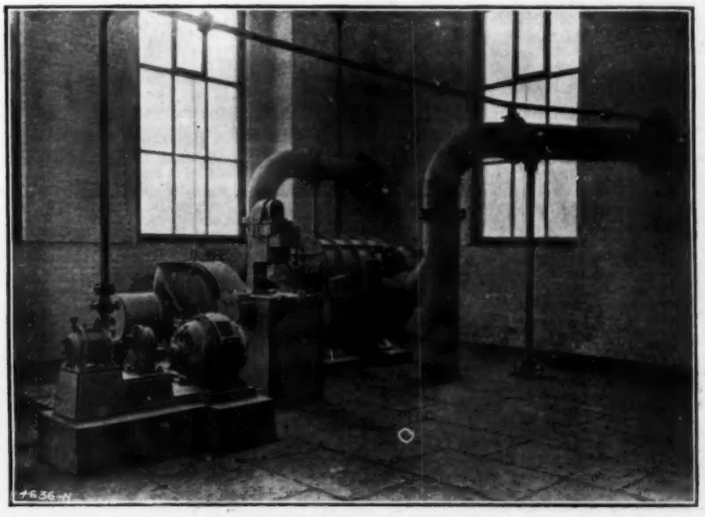


FIG. 7. ASH SUCTION PLANT.

vantageous, as it reduces the width of the boiler-room and the length of the chimney-stack, thereby causing a smaller resistance to the products of combustion. Each boiler has its own economiser, which is fitted with 256 tubes, 4-$\frac{7}{8}$ in. in diameter by 9 ft. long. The tubes are provided with electrically-driven scrapers. The induced fans are capable of dealing with the products of combustion from two boilers when working together. The fans were manufactured by Messrs. Musgrave and Co., of Belfast, and are provided with ring-lubricated, water-cooled bearings, and are driven by a 40-horse-power 440-volt three-phase motor, having a speed of 360 revolutions per minute. The motor is of the totally-enclosed squirrel-cage type (see Fig. 10, page 32).

The chimneys, manufactured by Messrs. Clayton, Son and Co., of Leeds, are made up of mild-steel plates varying from $\frac{7}{16}$ in. to $\frac{1}{2}$ in. in thickness. They are 6 ft. in internal diameter, brick-lined, the tops being 87 ft. 6 in. above the firing-floor level. The ash from the boilers, after passing over the back end of the grate, drops into ash-hoppers, and from that point is taken periodically, by means of Messrs. Babcock and Wilcox's suction ash arrangement, to a large receiver placed at the entrance to the coal-bunker roads (see Fig. 6). From this receiver, the ash, after having been cooled by a spray of water injected into the receiver itself, is loaded periodically into wagons at the main-line level. Provision is made so that soot from the economisers can be dealt with in the same way as the ash. Electrically-driven ash-breakers are provided between the ash-hopper and the suction ash-pipe. The ash-pipe is made of cast iron, and is 8 in. in diameter by 1$\frac{1}{4}$-in. thick. It runs along the ash-tunnel the full length of the boiler-room. In this pipe two inlet boxes are arranged underneath each boiler, so that the ash may drop straight into the ash-hopper, through the breaker, direct into these inlet-boxes. At the end of the main ash-pipe there is a bell-mouth opening for admitting air. The soot from the economisers is taken by a separate cast-iron pipe running underneath the economiser floor.

The ash-receiver has a capacity of 30 tons, and is provided at the bottom with a two-way shoot, so that the contents may be discharged into wagons on either of the roads which run over the coal-bunkers. The air-exhauster is motor-driven (see Fig. 7), and is of the Roots blower type, having a capacity of 3250 cub. ft. of air per minute, at a pressure of about 2$\frac{1}{2}$ lb. per sq. in. It was manufactured by the Sturtevant Engineering Company, U.S.A.

The coal-bunkers are situated in the centre of the boiler-room (see Fig. 9) and are filled by means of bottom-hopper wagons, the rail level being 37 ft. above the boiler-room firing floor level, and 7 ft. above the economiser-floor level. The hoppers are constructed of mild steel plating, and are of ample capacity, holding 50 tons of coal without trimming. Corrugated sheet-steel partitions separate the coal-bunkers from the economisers. Each boiler is fed by a separate hopper having two shoots, directing the coal into the receivers for the chain-grate stokers, suitable baffles controlling the supply.

A 30-ton weighing-machine is provided on the approach road for checking the coal supply. No weighing apparatus has been installed on the bunkers themselves. There are three coal-sidings for the exclusive use of the power-station; two are used for full and empty wagons respectively, having a capacity of twenty-four 20-ton hopper-wagons each, and the third siding is used chiefly for shunting purposes, and accommodates sixteen 20-ton hopper-wagons. Convenient connections are made with the up and down main lines, and the sidings are so arranged that unnecessary shunting is reduced to a minimum, and does not involve the main lines.

Turbine-Room (see Fig. 8, page 32).—The turbine-room is 188 ft. long and 64 ft. wide. The turbine-room floor consists of cast-iron non-slip grating. Suitable wells are arranged so that all auxiliaries in the basement, which is 20 ft. below, can be lifted directly by the crane. A 50-ton electric overhead travelling crane, made by Messrs. T. Broadbent and Sons, Huddersfield, is provided in the turbine-room, having a span of 61 ft., and travels the full length of the building.

5000-*Kw. Turbo-Alternator Sets.*—Two main generator sets, each having a normal capacity of 5000 kw., are installed. The turbines were manufactured by Messrs. Dick, Kerr and Co., Preston; they are of the impulse type, having a Curtis wheel at the high-pressure end, the remainder being of the Rateau principle. The speed is 1500 revolutions per minute. Each turbine has two rows of wolfram-steel blades on the velocity wheel, and ten rows of brass blades on the low-pressure wheel, the axial and radial clearances being 5 mm. and 7 mm. respectively. The governor gear of each turbine is fitted with a small electric motor, enabling the gear to be controlled from the main switchboard. The total weight of each turbo-alternator is 115 tons 16 cwt. Each alternator consists of a Dick-Kerr two-pole three-phase machine, generating at 6600 volts 25 cycles, and is capable of carrying 25 per cent overload for two hours, and 50 per cent. overload for five minutes.

The alternators are self-ventilated by means of fans fitted on the shaft at each end of the rotor. The air for ventilation passes through Heenan and Froude wet air-filters, each of which can deal with 25,000 cub. ft. to 30,000 cub. ft. of air per minute, the air passing through the filter at an approximate velocity of 1500 ft. per minute. Each turbo-alternator is complete with its own condensing plant, the latter being manufactured by Messrs. W. H. Allen, Son and Co., of Bedford, and consisting of condenser, steam-jet ejector, circulating-water pump, kinetic air-pump, extraction and delivery pumps (see Fig. 19, page 36). The condensers are of the surface type, of sufficient capacity to deal with 82,000 lb. of steam per hour, and are capable of maintaining a vacuum of 28.1 in. (barometer 30) at full load when supplied with cooling water at the rate of 6700 gals. per minute at a temperature of 75 deg. Fahr. The condensers have a diameter of 80 in., and each is fitted with 3464 tubes, having an internal diameter of $\frac{3}{4}$ in., the total cooling surface being 9500 sq. ft. The weight of each condenser (exclusive of water) is 38 tons.

The circulating-water pumps are of the "Conqueror" centrifugal self-regulating type with 20 in. diameter suction and delivery branches, and are capable of delivering 6700 gallons of water per minute, against a 35-ft. head when running at 485 revolutions per minute. Each pump is directly driven by a Dick-Kerr slip-ring induction motor of 110 brake horse-power. The steam-jet ejector is by a 1$\frac{1}{2}$-in. steam-pipe, and the estimated steam consumption is 0.75 per cent. of the turbine steam consumption. When on full load this will take 465 lb. of steam per hour. The kinetic air-pump (7 in. bore, 45,000 gallons per hour, 90-ft. head), extraction pump (5 in. suction, 3 in. delivery, 10,200 gallons per hour, 40-ft. delivery head), and the delivery-pump (3 in. suction, delivery 10,200 gallons per hour, 20-ft. head) are all mounted on one bed-plate, and driven by means of a Dick-Kerr 45-brake-horse-power slip-ring motor at 1450 revolutions per minute.

500-*Kw. Geared Turbo-Alternator.*—The power for the auxiliary apparatus is provided by a 500-kw. gear-driven turbo-alternator, built by the British Westinghouse Company, of Manchester (see Fig. 20, page 36). This set, which is complete with a surface-condensing plant, generates power at 440 volts 25 cycles, and the turbine is of the Westinghouse high-pressure "Impulse" type, running at 3600 revolutions per minute. The turbine has two rows of nickel-steel blades on the velocity wheel, and ten rows of nickel-steel blades on the low-pressure wheel, the axial and radial clearances being $\frac{1}{4}$ in., $\frac{7}{16}$ in., and $\frac{1}{4}$ in. respectively. The total weight of the turbo-alternator complete with gear and gear-case is approximately 30 tons.

The gearing, which gives a speed reduction of 3600 to 750 revolutions per minute, has been manufactured by Messrs. David Brown and Sons, Limited, of Huddersfield. The gear-wheel has a rim of special high-carbon steel, built up on a steel spider, and has 183 teeth. The pinion is made from solid nickel steel, and has 38 teeth, with a pitch of teeth 0.597 in., and a face width of 21 in. The generator is of the Westinghouse alternating-current engine type, capable of giving a continuous output of 500 kw. The condensing plant is on the Westinghouse-Leblanc patent system, and consists of condenser, circulating-water pump, air-pump, and extraction and delivery pump. A Westinghouse surface four-flow type condenser is used, which has a cooling surface of 850 sq. ft. It is capable of dealing with the turbine exhaust, and maintaining a vacuum of 27.5 in. to 28.5 in. (barometer 30 in.) on full load when supplied with cooling water at the rate of 784 gallons per minute, at a temperature of 75 deg. Fahr. It is 6 ft. 8$\frac{1}{2}$ in. between tube-plates, and contains 652 tubes of solid-drawn brass, $\frac{3}{4}$ in. O.D. and 18 I.W.G. The total weight is approximately 5 tons. The circulating-water pump is of the centrifugal type, having 8 in. suction and delivery branches, and is capable of delivering 784 gallons of water per minute against a head of 23 ft. when running at 1440 revolutions per minute. The air-pump is of the Westinghouse-Leblanc rotary valveless dry-air type, with a 4-in. suction branch and a 3-in. delivery branch. A centrifugal extraction and delivery pump is used, capable of delivering 11.6 gallons of water per minute against a head of 8 ft. when running at 1440 revolutions per minute. All the three pumps are mounted on one common bed-plate and driven by a 22-brake-horse-power motor, and the approximate weight of the combined set is 2 tons.

The hot-well (see Fig. 18, page 33) is arranged centrally between the main generators, and is of liberal capacity, holding 1460 gallons. It is divided into two compartments, so that the valves may be examined and the tanks cleaned and painted without putting it out of commission. Provision is made for a supply of make-up water from an auxiliary tank fed from the circulating water-mains. This water is treated in a softener, and the supply regulated by a 3-in. float-valve in the hot-well. An emergency connection is also taken from the town's main; this also is controlled by a similar valve operating at a lower level in the hot-well.

The condensate from the turbines is introduced at a point below the minimum water-level in the hot-well, so as to prevent aeration. Connections are taken from the underside of the hot-well, one from each division, uniting in a common main to the feed-pump suction. The water in the hot-well is heated by means of four 3-in. exhaust-steam ejectors, the exhaust steam being taken from the turbine feed-pump. Two test-tanks, mounted on weighing machines, are carried on the top of the hot-well, and arranged to work alternately and independently of each other. The condensates from all the sets are so conveyed to the hot-well that the condensate from any one set can be passed through the test-tanks, while the others are delivered directly to the hot-well.

A suitable tumbler, constructed to direct the flow of water into one tank or the other, is placed between and above the two tanks. By this means the water is diverted without interfering with the continuous delivery from the set under test. Each test-tank has a total capacity of 3800 lb. of water, discharging through a 6-in. quick-acting valve directly into the hot-well below. The weighing-machines are graduated to read zero when the tanks are empty.

Boiler-Feed Pump.—The station is at present equipped with two boiler-feed pumps, supplied by Messrs. Mather and Platt, Limited, of Manchester—one a turbine-pump, and the other a reciprocating pump, both capable of delivering 10,000 gallons of feed-water per hour against a head of 217 lb. per sq. in.

It is interesting to note that the reciprocating pump is the only reciprocating machine in the station. It is intended that the turbine-pump should be used in service, and the reciprocator as a stand-by. Both pumps are situated near the hot-well, and at such a level that they are always flooded (see Fig. 18). The turbine-pump is of the high-lift multiple-chamber type, absorbing 40 brake horse-power. It has a 5-in. suction and a 4-in. delivery, and is driven by a 45-brake-horse-power high-pressure turbine of the horizontal Curtis type, made by the British Thomson-Houston Company, of Rugby, and runs at 3000 revolutions per minute. The weight of the combined set is approximately 1 ton. The reciprocating-pump is double-acting, and makes thirteen double strokes per minute. Its chief dimensions are:—Cylinder, 10 in. in diameter, with a 24-in. stroke; suction branch, 6 in. in diameter; and delivery branch, 4 in. in diameter.

Spray-Pumps.—Two spray-pumps are installed for the purpose of dealing with the cooling of the circulating water. These pumps, with their motors, are exactly similar to the circulating-water pumps for the main sets.

Condensing water is obtained from the canal, and it passes first through a bar-screen, which stops the entrance of the larger pieces of floating matter, and then through rotary screens, which check the smaller weeds, &c., before reaching the cooling pond. The rotary screens, which are shown in Figs. 15 to 17 and 21, are two in number, each 10 ft. in diameter, and rotate at 1 revolution per minute. They are driven by Pelton wheels through worm-gearing; the water for driving them is obtained from the spray-pump discharge, and is under a head of 18 ft. When the spray-pumps are not working, the water is obtained from the auxiliary tank. The screens are cleaned by means of rotating jets, which spray on the exposed portion of the screens, on the side away from the incoming supply of cooling water.

The arrangement of the circulating-water pipes is shown in Figs. 11 to 14, page 33. The water flows from the cooling-pond into a brick-lined collecting-pit, and thence by gravity down a 45-in. pipe into the circulating-water suction-main. This suction-main has a maximum diameter of 62 in., and is of sufficient area to supply the demand of the whole station when extensions are completed. The present pipe supplies the two main condensers, the auxiliary condenser, also the water to the auxiliary tank, and is capable of easy extension as required. Water, having passed through the condensers, flows by gravity into a 62-in. diameter discharge-main running parallel with the suction-main. This pipe is fitted with suitable branches for future extensions, and discharges into a concrete channel running parallel with the canal, having outlets at convenient points. This channel is shown in Fig. 22. Connections are taken from the discharge-main to the spray-pumps, so that the hot circulating water can be pumped back to the cooling-pond through the spray-nozzles. Thus two methods of cooling are available, or a combination of both methods can be used at the same time. The discharge-pipe from the spray-pumps to the cooling-pond is 32 in. in diameter, and runs alongside the 45-in. diameter delivery-pipe from the pond.

Cooling-Pond.—The cooling-pond is 408 ft. long, 109 ft. wide, and 2 ft. 6 in. deep. The spraying arrangement has been supplied by Messrs. Harrison, Son and Jobson, Limited, Middlesbrough, and is capable of cooling 402,000 gallons of water per hour from 95 deg. Fahr. to 75 deg. Fahr. under normal atmospheric conditions, being so arranged that slight extension to the pipework will double the capacity, to 804,000 gallons per hour. The piping is constructed in four separate units, each unit being controlled by a valve situated in a convenient position on the pond side. Each unit is divided into three lengths of parallel piping, 32 ft. apart. Screwed in each pipe are 24 brass nozzles, spaced 3 ft. apart, thus making a total of 288 nozzles for the present plant. Each nozzle orifice has an area of 0.39 sq. in., and is capable of passing 1396 gallons of water per hour at a head of 18 ft. The circulating-water pipes have been manufactured by Messrs. Clayton, Son and Co., of Leeds, and at the railway company's works at Horwich.

Auxiliary Water Supply.—An auxiliary water supply has been installed to meet the demand for water other than that required from the town's main. This water is delivered into a storage-tank from the circulating-water suction-main by means of a Mather and Platt turbine-pump situated in the turbine-room basement. This pump has a capacity of 12,000 gallons per hour, against a head of 50 ft. when running at a speed of 1420 revolutions per minute. It has a 5-in. diameter suction and a 4-in. diameter delivery, and is driven by a 6-horse-power induction-motor. The pump and motor are mounted on one common bed-plate. The auxiliary tank is situated above the economiser floor, and has a capacity of 2900 gallons. The delivery water from the pump is controlled by a 5-in. float-valve in the tank. An emergency connection is taken from the town's main, and is controlled by a 3-in. float-valve operating at a lower level than the 5-in. valve. The auxiliary tank supplies water to the hot-well for make-up, to the main condensers for flooding purposes, to the oil-coolers, bearings, and numerous smaller details both in the turbine-room and the boiler-room.

Water-Softener.—The water-softener, manufactured by Messrs. Bowes, Scott and Western, Limited, London, has a capacity of 1000 to 1500 gallons of water per hour; it is 20 ft. 6 in. high, with a diameter of 6 ft. 3 in.; the decanter has a settling-tank capacity of 3940 gallons.

(To be continued.)

"THE BUILDER."—The new year's number of this journal contains a series of interesting articles, engravings, and sketches on the London churches of Wren and later architects of the Renaissance; on Wren's first design for St. Paul's; on the architecture of Flanders and Brabant; Italian architecture, &c.

DILUTION OF LABOUR AND EMERGENCY WORK.

TO THE EDITOR OF ENGINEERING.

SIR,—The Minister of Munitions, who has my deepest and solid support in the work he has undertaken, is unhappily a man entirely devoid of technical information, otherwise he would be able to be much more effective.

Take the congestion of work in engineering establishments, due to the fact that all joints about the engine, boiler, and even, I believe, skin of ship, have to be metal and metal. Surely no up-to-date engineer, if placed in an emergency position, would retain such practice for a moment; but anyone who has experience of Service methods knows that it matters not how devoid the office-holder may be of initiative, so long as he can confirm with boredom of "wait-and-see" Minute Paper palaver.

Many of the craft at present building are of a special class, and will, on the conclusion of war, be practically of no further service, and therefore the readiest means of production should be adopted. But as regards expedition and cost, such as are successfully attained by the engineers building our first-class liners, these craft can readily prove to be equal to the most exacting requirements.

This, together with the persistent refusal to use a cast-shell body in place of the steel body, the one being practically complete when cast, against the much more expensive and slower process of machining, would also dilute automatically labour, and solve the problem the Minister of Munitions has before him.

One might as well expect to secure the benefits of sea bathing by compelling a man to put on a diving-suit before entering the sea, as to expect to secure early victory by incompetent handling of our resources. We, as a nation, can defy the world in resourcefulness. But we must not attempt to transfer the general office staff to the machine-shop and expect to get the same results; to govern an engineering works it is essential to have an engineering head, and the same applies throughout every line of life. We never find a retired colonel appointed to the Lord Chancellorship, Attorney-Generalship, or Solicitor-Generalship, but to a post he understands. H.M.S. Pinafore recital "Stick to your Bench, and never go to Sea," is only too seriously true.

Yours faithfully,

DAVID A. SHERET, A.M.I. Mech. E.

Enerdale House, Heaton Grove, Newcastle-on-Tyne,
January 5, 1916.

TORSION STRESSES IN FRAMED STRUCTURES.

TO THE EDITOR OF ENGINEERING.

SIR,—I regret that circumstances have prevented me from answering Professor Batho's letter of November 29, which appeared on December 17.

In my letter of November 5, which appeared on page 466, no exception whatever was taken to the application of Professor Batho's method of solving the problem as applied to the torsion of framed structures in which the relative size of the members is small, under which circumstances accurate results are to be expected. When applied to the case of hollow prisms having continuous boundaries, however, the results obtained are entirely at variance with the modern theory of torsion which has been amply confirmed by experimental research.

Referring to Fig. 3 of Professor Batho's paper, on page 392 (October 15) it will be seen that the shear stress at two points on the contour distant δs apart is *assumed* to be the same, and this without the least justification. By taking moments and integrating round the whole contour of the prism, the following formula is obtained:—

$$S = \frac{T}{2A} \frac{b}{},$$

where S is the total shear, b is the length of the prism, T equals the torque, and A equals the area of the base of the prism. It would therefore appear that the shear is independent of the ratio $\frac{\text{major axis}}{\text{minor axis}}$ for the same area of section, leading to the conclusion that a section in which this ratio is very large is as efficient as one in which this ratio equals unity—*i.e.*, when the section is circular. Such a conclusion is, of course, contrary to all experience.

In the case of sections having non-continuous boundaries—*i.e.*, rectangular and polygonal sections generally—the effect of the corners is equally in evidence whether the walls be thick or thin. St. Venant in his classical memoirs on torsion has deduced expressions for the stresses in solid and hollow prisms subjected to a twisting moment, and these have been fully confirmed by experimental research. In the case of hollow rectangular prisms, St. Venant demonstrated conclusively that a condition of zero stress exists at the corners of such prisms; moreover, St. Venant's formula for hollow rectangular prisms only applies rigidly when the walls are infinitely thin. Experiments carried out by the writer on the torsion of hollow rectangular prisms gave results which differed from St. Venant's results by only about 2 per cent., while it was found that a hollow section, 1.50 in. square by 0.05 in. thick, developed 86.7 per cent. of its geometrical strength, as compared with 84.3 per cent. as obtained from St. Venant's formula for a solid square section. The above hollow section cannot, strictly speaking, be assumed to have thin walls in the mathematical sense, but the above figures indicate that the nature of the surface stress distribution in a hollow section is similar to that in a solid section of the same shape. It is inconceivable that the nature of the stress distribution could be materially altered by thinning the walls.

Professor Batho seems to have some misconception as to what is meant by "the warping of sections at right angles to the axis of twist." This does not refer to the closing in of adjacent plane sections, but refers to the alteration in shape of any *one* cross-section of the prism under the application of a torque.*

In regard to Antenrieth's formulæ, it may be pointed out that these were obtained in an entirely different manner from those of St. Venant. Discrepancies were therefore to be expected; and, moreover, in all cases of interest to the engineer, agreement is fairly complete. Antenrieth's formulæ do not refer only to thick-walled hollow sections, but are equally applicable to those having thin walls.

A clue to the condition of stress in a thin-walled hollow prism subjected to a twisting moment may be obtained from a consideration of its hydrodynamical analogue. If we consider the walls of the prism to be fluid, constrained by the outside and inside boundaries of the prism, and if this fluid is given a uniform spin so that its angular velocity is constant, then the stress at any point is represented by the linear velocity of the fluid at that point. In the case of a hollow rectangular prism, at the corner the fluid suffers a sudden change of direction at right angles to its original direction, with the result that at this point the velocity in the original direction is zero, and in consequence the stress at this point must also be zero. Clearly this applies whether the walls be thick or thin.

In the case of hollow polygonal sections such as the hexagon, &c., the stress at the corners will not be zero, since at the point of change the fluid has a component of velocity in its original direction, this being in accord with Antenrieth's deductions.

In his demonstration on page 623, Professor Batho does not by any means justify the methods he used in his original paper. Not only does he assume that the element δs suffers a change in length under the application of a torque, which in itself infers a difference in stress at the two ends of the element, but he proceeds to ignore this by using his theorem 3, the fallacy of which has already been pointed out.

The extension of Professor Batho's method to the case of solid prisms would indeed be interesting, even if such extension yielded only approximate results.

Faithfully yours,

ERNEST G. RITCHIE.

Engineering Department, University College, Dundee,
January 12, 1916.

SHELLS; MORE SHELLS.

TO THE EDITOR OF ENGINEERING.

SIR,—Permit me to offer a criticism on this correspondence.

1. "Shells; more shells," should read, shell *bodies;* more shell bodies.

2. Shell *bodies* of pressed steel to the stringent Government specifications are now, and have been for some time, obtainable in sufficient quantity to meet the demand for *shells.*

3. This is ascertainable with some trouble, but cannot be officially published.

4. However thermally treated, any *casting* can never be rendered as reliable as the pressed steel now used.

5. Tensile strengths up to the amount mentioned are, and have been, obtainable for many years with thin malleable castings, but not over $\frac{3}{8}$ in. thick.

6. The mixture given (in which, by the way, the limits given sufficiently neutralise their value) is an ordinary refined malleable pig, such as has been made in Middlesbrough and other places for the past twenty years.

7. There is nothing novel in annealing, except by quoting ½d. per pound, instead of 4*l.* 13*s.* 3*d.* per ton.

8. Your correspondent should ascertain the total weight of pressed steel shells being turned out per week, and then compare it with the estimated weight which could be turned out by the plants he thinks available for making his proposed metal; also the cost for providing further suitable plant; and he will at once see the absurdity of the proposals which he has been lured into advertising.

9. The idea of applying the term "inventor" to any one proposing a certain mixture or advocating a heat treatment carries its own criticism; a more suitable appellation can be found in Macaulay's essay on Mr. Robert Montgomery.

10. Your Openshaw correspondent very ably criticises the proposals, and these few remarks may help to substantiate his observations.

Yours truly,

January 10, 1916. INDEX.

TO THE EDITOR OF ENGINEERING.

SIR,—I have followed with much interest the correspondence *re* cast-iron shells which has appeared of late in your columns. From what I can gather, the majority of your correspondents do not see any special difficulty in replacing steel shells by shells made of cast iron. Personally I am not over-sanguine of the results of such a change, and the whole difficulty would seem to rest in the premature collapse of the shells.

Cast iron occupies a unique position amongst the metals used in the arts, for it is probably the most brittle of these metals, its elastic limit being for all practical purposes nil. The sudden propulsive and concussive forces of such a magnitude as is produced in our modern guns acting on the shell, in which there are at given points variations in mass and differences in direction of dimensions, would set up a tendency for these masses to part company; and were the shell made of cast iron, internal cracks at least would be formed, even if it did not immediately collapse; hence premature bursting might be expected as a regular occurrence in such shells. In addition, the strength of cast iron rapidly falls with rising temperature, and a considerable drop in strength is noted even at temperatures from 60 deg. to 100 deg. Cent. This would also assist in the premature bursting of cast-iron shells under such conditions as obtain in the modern gun.

Undoubtedly cast iron will not satisfactorily replace steel for the manufacture of ordinary shells; but, at the same time, I am of the opinion that much greater use could be made of cast iron in such implements as the "low-velocity trench-guns" spoken of by your correspondent Frederick Mann. It might be of interest in this connection to point out that cast iron can be produced having a certain amount of elasticity. This is by no means an entirely new thing, for a sample of cast iron (*fonte speciale*) "capable of forging" was exhibited at the Paris Exhibition in 1900.

In connection with the use of malleable cast iron, the great difficulty with this metal would be that of maintaining uniformity of composition and homogeneity of structure. Your correspondent aforementioned, in his letter of January 7, gives one to understand that a cast iron of 0.45 per cent. phosphorus content is of necessity a close-grained iron. This is not so, for the grain size of cast iron does not depend on the phosphorus content.

Trusting this letter will not occupy too much of your valuable space,

I am, yours truly,

J. EDGAR HURST.

15, Manchester-road, Tintwistle, Cheshire,
January 12, 1916.

* See Todhunter and Pearson, "History of Elasticity," vol. ii., Part I., page 27.

THE FIRST ELECTRIC TELEGRAPH.

TO THE EDITOR OF ENGINEERING.

SIR,—I was extremely pleased to read Mr. Atkin's letter of the 28th ult, drawing attention to the first electric telegraph, 8 miles long, constructed at No. 26, Upper Mall, Hammersmith—Kelmscott, 1816, by Sir Francis Ronalds, F.R.S. Might I venture to state that the first step for the use of electricity for telegraph wire was taken by Mr. Charles Morrison, a native of Greenock, who wrote a most interesting article on "An Expeditious Method of Conveying Intelligence," in the *Scots Magazine*, dated February 1, 1753.

Dr. Morrison communicated his idea to Sir Hans Sloane, who approved of his method of constructing the telegraph wire. The late Sir David Brewster, the eminent Christian philosopher and principal of the Edinburgh University, stated that the idea of the practical application of the transmission of messages was undoubtedly first suggested by an article in the *Scots Magazine*, 1753.

Yours most sincerely,

JOHN W. GRANT, A.M.C. Inst. (Lond.)

Greenock, January 5, 1916.

OPENINGS FOR BRITISH TRADE.—The *Board of Trade Journal* for the 6th inst. publishes a further statement to the effect that applications had been received at the Commercial Intelligence Branch, 73, Basinghall-street, London, E.C., from a large number of firms in all parts of the United Kingdom, who wish to enter into communication with United Kingdom manufacturers and producers of various classes of goods which have previously been obtained from Germany and Austria-Hungary. The *Journal* gives the list of the goods in question.

COAL IMPORTS INTO ITALY.—The statistics published by the journal *La Metallurgia Italiana* give the following figures for the coal imports, in tons, into Italy:—

Proceeding from	1913.	1914.	August to December, 1914.	January to October, 1915.
	tons	tons	tons	tons
Great Britain ..	9,396,132	8,485,121	3,143,678	5,514,191
Germany	967,774	836,937	220,045	436,251
France	164,674	67,244	14,572	23,170
Austria-Hungary ..	133,978	66,474	10,736	15,740
United States ..	93,528	291,644	119,509	896,216

OUR LOCOMOTIVE EXPORTS.—The war greatly reduced last year the exports of locomotives from the United Kingdom, but deliveries were still upon a considerable scale, the aggregate value attained for the twelve months having been 2,476,407*l.* In this total deliveries to Argentina figured for 268,595*l.*; South Africa took our locomotives in 1915 to the value of 54,513*l.*; British India to the value of 1,586,080*l.*; and Australia to the value of 73,883*l.* The yearly value of the locomotives exported in the ten years ended with 1915 inclusive was as follows:—

Year.	Value.	Year.	Value.
	£		£
1906	2,896,293	1911	2,307,020
1907	3,432,841	1912	2,187,198
1908	2,729,065	1913	2,781,856
1909	2,381,145	1914	3,840,262
1910	1,707,747	1915	2,476,407

The greatest falling off in last year's exports as compared with 1914 occurred in those made to Argentina, British India and Australia. Argentina was suffering during the past twelve months from agricultural and general depression, which the war aggravated; the Anglo-Indian Government restricted its commitments on the outbreak of hostilities; and the Antipodes were almost as much affected as Europe by the great struggle.

ELECTRIFICATION OF THE MANCHESTER TO BURY SECTION; L. AND Y. RAILWAY.

(For Description, see Page 28.)

FIG. 8. TURBO-GENERATOR ROOM.

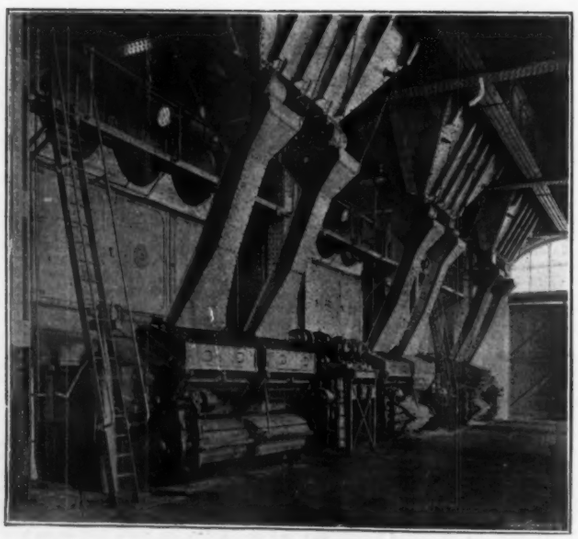
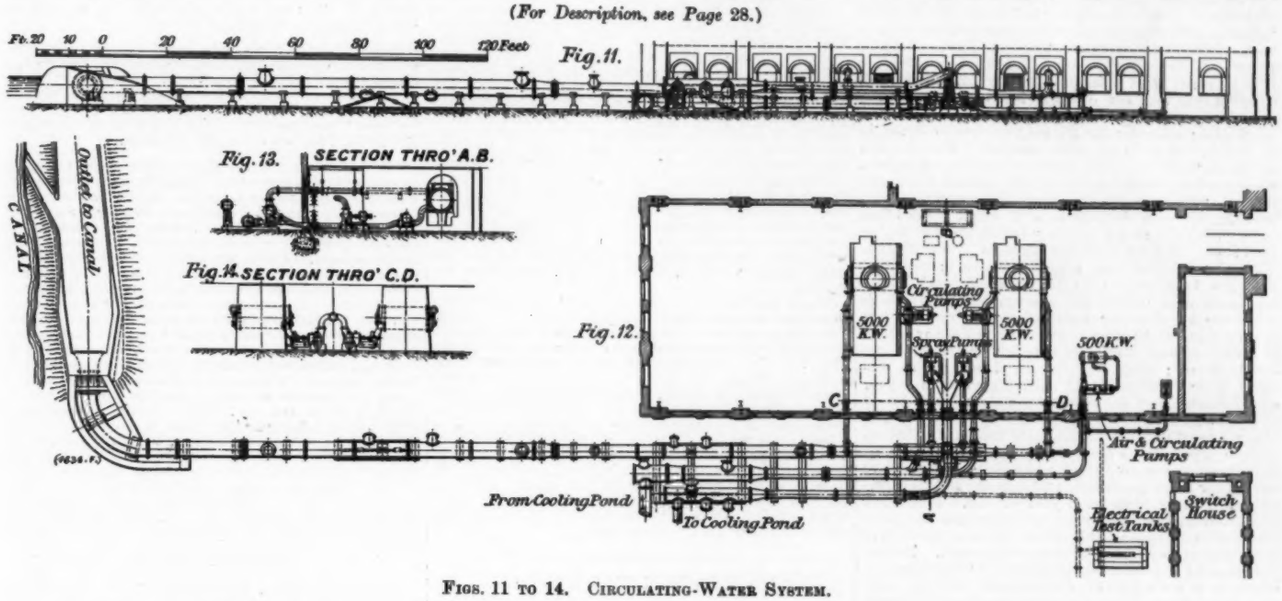


FIG. 9. BOILER-ROOM.

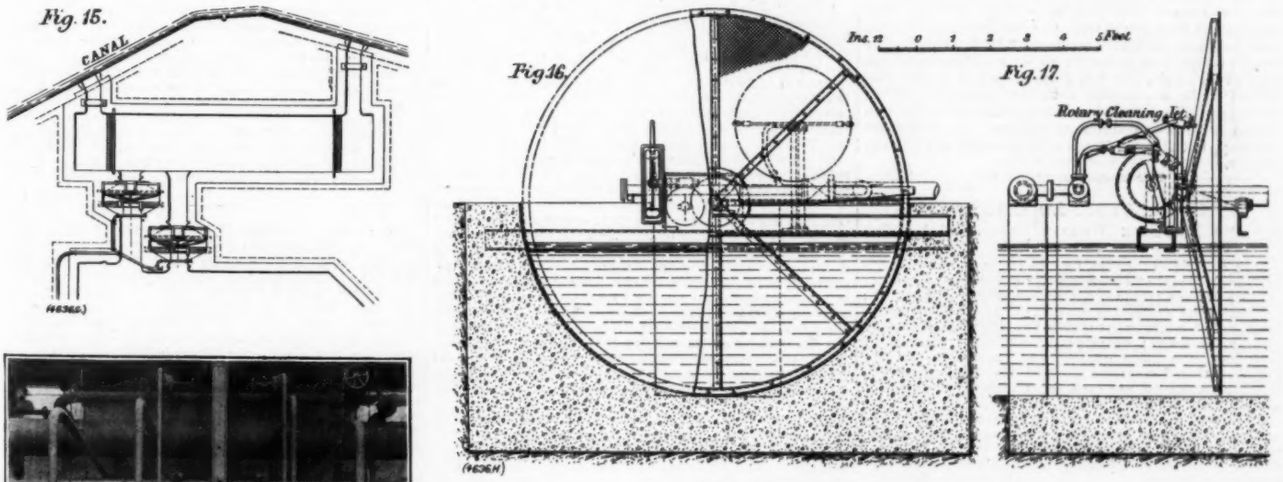
FIG. 10. INDUCED DRAUGHT FAN AND MOTOR.

ELECTRIFICATION OF THE MANCHESTER TO BURY SECTION; L. AND Y. RAILWAY.

(*For Description, see Page 28.*)



FIGS. 11 TO 14. CIRCULATING-WATER SYSTEM.



FIGS. 15 TO 17. ROTARY SCREENS.

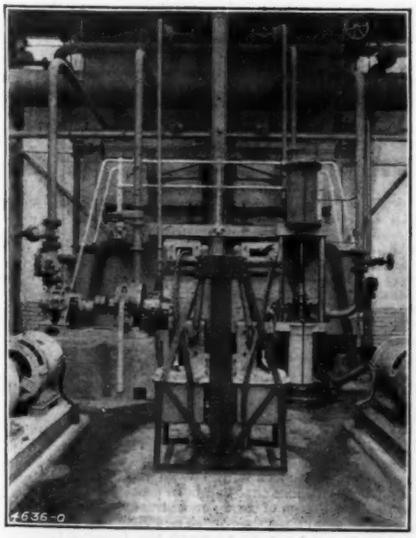


FIG. 18. BOILER FEED-PUMPS, TEST TANKS AND HOT WELL.

UNIVERSITY OF LONDON, UNIVERSITY COLLEGE.—A course of six lectures on "Electrical Production of Nitrates for Fertilisers and Explosives" will be delivered by Mr. E. Kilburn Scott, M.I.E.E., A.M. Inst. C.E., on Wednesdays, at 5.30 p.m., beginning January 26, 1916. The first lecture is open to the public without fee or ticket. The course is open both to members and non-members of the University; fee, 1*l.* 11*s.* 6*d.* Application for tickets of admission to be made to Mr. Walter W. Seton, M.A., D.Litt., Secretary, University College, Gower-street, W.C.

SHELL-MAKING IN AUSTRALIA.—According to information received through the intermediary of the High Commissioner for Australia, the Australian Munitions Committee received nineteen tenders from firms in the Commonwealth prepared to make shell bodies. The Minister for Defence states that the tenderers intimated their willingness to accept the flat rate. As many shells as contractors can produce will be accepted up to June 20, 1916, and all those that can be manufactured and delivered up to March 31, 1916, will be paid for at the flat rate of 21*s.* per shell body, complete, delivered f.o.b. Steel which has passed rigorous tests has been provided by the Broken Hill Proprietary Company, and a first supply has been shipped to all States, and sample quantities can be supplied as required. Bars 3½ in. wide by $\frac{7}{8}$ in. thick will be required for base-plates in the proportion of 1 ton to 25 tons of round bars. The Broken Hill Proprietary Company is arranging to have bars of this size rolled from the billets in Melbourne. The price of these flat bars to manufacturer will be 10*l.* per ton, plus freight. As the results of trials with several types of bomb, 10,000 of a type, modified by Mr. R. J. Lewis from the original design, have been ordered for manufacture and despatch to the front. Larger quantities will be manufactured if the demand arises.

INDUSTRIAL GAS.—On Monday, the 10th inst., Mr. H. M. Thornton delivered a lecture before the Derby Society of Engineers on "Industrial Gas, its Services to the Nation," the gas in question being town or coal-gas. The lecturer divided furnaces into:—(A) Natural-draught furnaces, used for temperatures up to 800 deg. Cent.; (B) furnaces with gas at low pressures and fan-draught for temperatures between 800 deg. and 1400 deg. Cent.; and (C) low-pressure gas and air-blast, or high-pressure gas for small furnaces, where high working temperatures are required in a small furnace. The first is heated with a series of Bunsen burners, which enter the combustion-chamber of the furnace. Combustion is supported and intensified by secondary air entering the combustion-chamber, playing under the furnace floor and surrounding the walls and roof. This will heat up from cold to 800 deg. Cent. in 50 minutes. Another furnace resembling this is the natural-draught reverberatory oven furnace. In this the combustion-chamber is the working-chamber also. Hot air from passages in the furnace bottom meets the gas at the point where combustion takes place, and the flame passes on the underside of the furnace roof. This furnace is satisfactory for temperatures up to 1000 deg. Cent. The B furnace, known as the "L.P.G.A." (low-pressure gas and air), can be constructed either in the gas or oven type. The whole of the air supply is heated, and it is unnecessary to employ the usual Bunsen burners with secondary air supply. Steel has recently been annealed in such a furnace capable of taking 8 or 9 tons, with a consumption of 3000 cub. ft. per ton, when 6 tons were being treated per charge. The reheating of billets for rolling has been achieved in Sheffield at the rate of under 3000 cub. ft. per ton. In the C type, a furnace for hardening cutters, measuring internally 18 in. by 15 in. by 9 in., can be heated up to 1300 deg. Cent. in one hour, and kept at that for about 400 cub. ft. of gas per hour. In the manufacture of munitions a L.P.G.A. furnace will take a load of 2½ tons, and will anneal carbon steel in bars at about 3000 cub. ft. of gas per ton.

NOTES FROM THE UNITED STATES.

PHILADELPHIA, December 29.

THE terrible congestion of freight and the increasing shortage of coke is disrupting conditions in the steel industry to a most serious extent; some furnaces have been banked up for want of coke. The scarcity of pig-iron is becoming serious; every furnace available is in blast; so great is the pressure for furnace and mill supplies that very few concerns feel safe in accepting business for delivery after June 30. Pig has advanced to 20 dols.; an order for 30,000 tons was squeezed in at Buffalo for delivery next summer. Foundrymen in the East are borrowing from each other. American makers of munitions have to bid against European buyers, who stop at no price. Inquirers are now pressing for over 600,000 tons of large rounds and other forms of steel for delivery during the last half of 1916; one inquiry—250,000 tons—is from France. Neutral countries are urgent inquirers; wrought iron has been turned to in place of steel. Bars are scarce and billets are scarcer, and some mills will have to close for want of them; steel billets are 36 dols. to 40 dols. Western mills have been shipping billets East; cold-rolled shafting is up 5 dols. a ton; hoops and bands, 2 dols.; wire products, 2 dols., which is 12 dols. higher than a year ago. Shipbuilders are pushing in orders for plates at any price named, and mills are sold up to July 1. The heavy export demand for tin-plate has sent prices up to 3.75 dols. Much more structural iron is called for than it is possible to supply; building operations are calling for large quantities, and activity in this direction is greater than for a year or two. It is mere repetition to say that mills and furnaces are overwhelmed with orders and that a great many buyers must wait the convenience of manufacturers. Part of the material wanted under pressure is for exportation, where it is not a matter of how much, but how soon. As matters stand, American consumptive requirements must take their turn and be content with the best that can be done for them. Car-builders report much more business in sight than is actually presented. The freight congestion continues to be a serious problem from every angle, and the general public is not permitted to be acquainted with the magnitude of the obstacles. The industries directly and indirectly connected with war conditions are working at highest capacity, but shipments are slow and cars are getting scarcer.

THE ELECTRIC LOCOMOTIVE.*

By FREDERICK WILLIAM CARTER, M.A., Assoc. M. Inst. C.E.

THE electric locomotive for use on main-line railways has already reached a high state of development in countries where conditions are favourable to electrical operation; the number of distinct types that have been developed is large, and it is somewhat difficult to classify them simply and satisfactorily; development has taken place along two lines, one based on tramway experience and the other on steam-locomotive practice. Electric locomotives, suitably controlled, are capable of making very efficient use of their adhesive weight for developing draw-bar pull, and on this account electrical operation often shows to advantage where gradients are long and steep. Where such conditions prevail, the question of the return of energy to the source, by using the motors regeneratively, becomes of interest.

Electric locomotives admit of a primary division into two groups—namely, those in which the axles are driven independently and those in which they are coupled and driven collectively. With a few exceptions these two groups correspond with the continuous-current and the alternating-current systems of operation respectively, and have their origin in limitations of motor design. With the exception of the Pennsylvania Railroad locomotives, all important side-rod locomotives have been designed for alternating-current systems. With the exception of the Norfolk and Western locomotives, all driving through jack-shafts have been designed to use single-phase commutator-motors; with the exception of the later Lötschberg locomotives, all driving through Scotch yokes employ polyphase-motors. Two methods are used for driving the axles independently—namely, the geared and the gearless; unless the driving is arranged to be effected through a spring-supported quill, both methods add to the dead weight carried by the axle; the amount of the additional weight is of interest from its bearing on the maintenance of the parts. Collective driving through side-rods assumes several forms, but all result in considerable strains in the structure. Where the locomotive is driven by motors of uniform torque the main driving forces cause alternating stresses of low frequency in the structure, but where the driving torque is impulsive the resultant frequency becomes comparable with the natural frequencies of vibration of some of the parts, and at certain speeds destructive vibrations are liable to be set up from resonance between the frequency of the main driving torque and the natural frequency of vibration of some part or parts; vibrations of smaller intensity and varying with the adjustment arise from indeterminateness in the application of the driving forces, and such vibrations are also met with in steam locomotives. The polyphase locomotive from its constant speed characteristics is less likely to be affected with vibration troubles than others.

The classification of locomotives according to wheel arrangement has been adopted from steam practice, but hardly affords the same insight as to the type as in the case of the steam locomotive. Electric locomotives have not always been designed with due regard to the question of stability of the rolling motion of the wheels, and some run less smoothly than is desirable on this account. The tilting of the rails and the coning of the wheels causes the progression, by pure rolling, to assume a sinuous nature, and on the stability or instability of this motion depends the question whether the nosing effect tends to die down or to increase to the limits permitted by the wheel-flanges. It can readily be shown that a locomotive carried on a rigid wheel-base is in some circumstances unstable, and may accordingly be expected to develop a nosing tendency if run at high speed; the same is true when the locomotive is divided into units, each carried on a rigid wheel-base; guiding-wheels, elastically centred to align with the main wheels, tend, however, to stabilise the motion.

There are few available records of tractive-resistance tests on locomotive-drawn electric trains; but among the most complete are those taken by the General Electric Company in connection with the endurance test on the first New York Central and Hudson River Railroad locomotives. These were made on trains of two different types of passenger-vehicle, and are of importance in showing very conclusively that, for a particular type of coach, the additional tractive resistance per additional coach is a function of the speed, and is independent of the number of coaches, provided this is greater than two; the additional tractive resistance per additional coach was found to be a straight-line function of the speed within the limits of the tests. The effective locomotive resistance when running with a train was found to be smaller than that of the locomotive running alone.

* Abstract of a paper read before the Institution of Civil Engineers, on Tuesday, January 11.

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Glasgow Pig-Iron Market.—Prices of Cleveland warrants were slightly irregular last Wednesday, and in the forenoon cash values fell to 78s. 1½d. per ton. At the close sellers' cash quotation was 78s. 3d., while that for one month's iron was 78s. 9d. The business done amounted to 2500 tons. A certain recovery was made in the afternoon, and while cash iron was completely idle, one month's iron changed hands at 78s. 11½d. Closing sellers' prices were 78s. 6d. cash, 78s. 7d. eleven days, and 78s. 11½d. one month. Dealings were restricted to 1500 tons. Friday morning's market again showed a tendency towards irregularity. Cash warrants changed hands first at 78s. 6d., dropping to 78s. 2d., then recovering to 78s. 4½d., with sellers over at this figure at the close. One month's iron realised 78s. 11d., one transaction being included in the turnover of 3000 tons. Although prices remained steady in the afternoon, practically no business was done, only one cash warrant being dealt in. Closing sellers' prices were ½d. per ton over the forenoon's level. Cash warrants represented the only transactions on Monday morning, 2000 tons being dealt in at 78s. 3d. per ton. The close was firm, and for cash iron sellers' quotation was 78s. 6d., and for one month 78s. 11½d. A further improvement took place in the afternoon, when 78s. 5½d. was realised for four days and 79s. one month, with closing sellers 78s. 7½d. per ton cash and 79s. 1d. one month. The turnover amounted to 1000 tons. Yesterday (Tuesday) morning a steady tone prevailed, and at odd dates 2500 tons of Cleveland warrants changed hands, the prices including 78s. 6d. six days, 78s. 7½d. ten days, and 78s. 9d. seventeen days, with cash and one month closing sellers at practically the same rates as on the previous day. Prices dropped a trifle in the afternoon, but it only meant 1½d. per ton on cash iron and 2½d. one month. A small business of 1500 tons was done. Business was rather dull this morning, when the tone was decidedly flat, Cleveland warrants dropping 4d. per ton, to 78s. 2d. cash and 78s. 9d. one month, with sellers over at this latter price.

Sulphate of Ammonia.—Sulphate of ammonia continues firm, alike in demand and in price, and in view of the fact that in the very immediate future the demand will be considerably increased, the present high rate seems ominous. For prompt delivery Glasgow, the price remains the same as last week, 17*l.* 15s. to 18*l.*; and at Leith, 18*l.* 5s. per ton.

Scotch Steel Trade.—Although many of the local works started up after the holidays on Wednesday or Thursday, others again were unable to get into full swing until Monday, owing to the extent of the repairs rendered necessary by the strain of the past five months. The scarcity of coal and raw material has been another cause of delay, but any time which may thus have been lost will speedily be made up again. There is every indication that in the months to come an increased activity will be noted, particularly as manufacturers have many orders to overtake. The recent visit of Mr. Lloyd George has shown, too, that the West of Scotland is destined to play a very prominent part in the supply of munitions of war, and that so long as the war lasts will it be necessary to do all possible to keep the output at top level. The suggestion having been made that a maximum price be fixed for all steel manufactured for the home market it is probable that manufacturers will shortly be approached on the subject. Considering the present high rate of hematite, it is not easy for Scotch steelmakers to make any definite arrangement in the meantime. In all directions the greatest briskness prevails, particularly with orders on Government account, but so far there is not the least probability of any change taking place with regard to ordinary mercantile business. Plates and sectional material are much in demand despite the heavy prices which are unchanged from last week:—Boiler plates, 13*l.* 10s.; ship-plates, 12*l.* 10s.; and angles, 13*l.* to 13*l.* 10s.—all less the usual 2½ per cent. for prompt delivery.

Malleable-Iron Trade.—As in all else, the malleable-iron manufacturers report excellent business, the pressure remains great, prices firm and high. Everything possible is being done to increase the already enormous output, but, of course, distinct difficulties are in the way. "Crown" bars are still quoted the same as last week—13*l.* to 13*l.* 10s., less 5 per cent. discount.

Scotch Pig-Iron Trade.—The increased freight charges, in adding to the price of ore coming into the country, are already responsible for a further advance in the price of makers' iron, both No. 1 and No. 3, and these are likely to remain very firm. Indeed, some of the best brands are now quoted at over 5*l.* per ton, a price sensational in the extreme. While the taking over of the pig-iron-producing works by Government was not unlooked for, it is expected that much better conditions will now prevail. It is felt that it is only reasonable to put raw material and the finished article on an equal footing, and thus ensure Government control both of material and labour. Nor is the financial aspect lost sight of, for thus both producer and customer will benefit. The shipments of pig-iron for the week ended January 1, 1916, amounted to 4611 tons, a very considerable increase on the 2298 tons recorded for the week ended January 2, 1915. During the past week sixty-four blast-furnaces have been in operation in Scotland, which is seven fewer than in the previous week, and nine fewer than at the corresponding date a year ago. Makers' (No. 1) iron is now quoted as follows:—Clyde, Calder, Summerlee, and Langloan, 103s. 6d. per ton; Gartsherrie, 104s. 6d. (all shipped at Glasgow); Eglington, 98s. 6d., and Glengarnock, 102s. 6d. (both at Ardrossan); Dalmellington, 98s. (at Ayr); and Shotts, 103s. 6d. (at Leith).

TRADE WITH HONG KONG.—The Board of Trade are notified by the Colonial Office that, according to telegraphic information from the Governor of Hong Kong, complaints are being received there that some merchants in the United Kingdom are declining to complete or undertake orders from Hong Kong merchants on the ground that such merchants are not on the white list of persons and bodies of persons to whom articles to be exported to China may be consigned under the terms of the Proclamation of September 24, 1915 (see pages 952-953 of the *Board of Trade Journal* of September 30 last). Special attention is drawn to the fact that the Proclamation referred to does not apply to Hong Kong; Hong Kong is not affected by the white list regulations.

TRADE WITH CHINA.—H.M. Commercial Attaché at Pekin reports that the Chinese Ministry of Agriculture and Commerce have recently established a Commercial and Industrial Commission whose object is the collection of statistics and the development of trade in China, and that this Commission desires to receive copies of catalogues issued by United Kingdom manufacturers. United Kingdom manufacturers and importers of United Kingdom goods, who may be interested, should address catalogues and price-lists of their goods to the Commercial and Industrial Commission, Ministry of Agriculture and Commerce, Pekin. The Commercial Attaché also invites publishers of periodical trade publications to send specimen copies of their publications, noting amount of annual subscription to each, to the Commission, with a view to the publications being considered for addition to the library which the Commission is installing for the assistance of Chinese importers and exporters in making connections abroad.

AUSTRALIAN METALS.—At the conclusion of a Conference in Melbourne recently, in connection with the local treatment of Australian copper and zinc, the Commonwealth Prime Minister said that satisfactory arrangements had been made by the Morambora Copper Company to have all its matte treated at the Wallaroo and Moonta Works, South Australia, and negotiations had been opened between the Hampden-Cloncurry Company and the Wallaroo Company to refine its blister copper after the removal of the gold and silver contents by bottoming. With reference to the question of the manufacture of copper goods, negotiations which had been proceeding for some months with the view to the establishment and manufacture of plant for turning out all wire, rod, sheet, tube, and bar copper and brass required by the Commonwealth, had now reached a stage when a definite result might be looked for. Within a comparatively short time it was hoped that the copper-manufacturing industry would be an accomplished fact. Certain negotiations that had been proceeding in London for the distillation of zinc concentrates into spelter had not yet come to a conclusion. The Prime Minister added that he would probably approach the Imperial Government, when in England, with a view to urging that immediate steps be taken which would enable the treatment in Great Britain of the surplus concentrates of the Commonwealth. He further stated that he had had another conference with the general manager of the Sulphides Corporation with regard to the treatment of lead concentrates. A proposal was to be submitted to the London Board by the general manager; in the conversations with the latter, special stress was laid upon the importance which the Government attached to its policy of treating all metallic products in Australia.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Hull Coal Traffic.—Last year's coal imports to the port of Hull show a decrease of nearly 1,000,000 tons compared with those of 1914, which is attributed to the restriction of exports of coal both to neutrals and our Allies. Last year 4,667,733 tons were imported to Hull from the South Yorkshire pits, as against 5,652,633 tons in 1914. The receipts in December last amounted to 273,943 tons, compared with 398,417 tons in the corresponding month of the preceding year. Foreign exports from Hull also show a marked decrease. Last year's exports amounted to 2,449,936 tons, compared with 2,968,801 tons in 1914. Only 85,619 tons were shipped abroad during December, as against 191,260 tons in December, 1914. An extraordinary increase has been shown month by month in the exports of coal to France. Last year she took over a million tons more than in 1914, the figures being: 1915, 1,553,831 tons; 1914, 469,496 tons. The general export figures do not include coal shipped for Admiralty purposes or the use of the Allies' Governments. Last month 28,795 tons, which were received at the port, were exported to London and other home ports, making a total of 588,807 tons sent coastwise during the year. A comparison of annual figures show that last year's imports were exceeded by 1913 imports by no less than 3,278,232 tons. The two largest customers for the year were France and Sweden.

South Yorkshire Coal Trade.—The demand for house qualities is strong, and merchants find difficulty in dealing promptly with orders. Gas-fuel is in brisk request, both on home and foreign account. A large tonnage is being shipped to France, which is now relying almost solely on the British market for supplies. Notwithstanding Government support, considerable difficulty is being experienced with regard to freights. Licences are being refused applicants for export to neutrals, and shipments are only on a moderate scale at the Humber ports. The situation with regard to best hard coal shows little change. The demand still exceeds the supply, and there is practically nothing on the open market. Cobbles and nuts are in great request for munition and other work, the furnace demand for cobbles being exceptionally heavy. Collieries are being pressed for slacks, but have no free supplies, their output being absorbed under contract. Delay in transit makes the decreased production have a marked effect at the dépôts. Cokes remain firm at their recent high level. Quotations:—Best branch hand-picked, 20s. 6d. to 21s. 6d.; Barnsley best Silkstone, 17s. 6d. to 18s. 6d.; Derbyshire best brights, 17s. 6d. to 18s. 6d.; Derbyshire house, 16s. to 17s.; best large nuts, 15s. to 16s.; small nuts, 14s. 6d. to 15s. 6d.; Yorkshire hards, 16s. 6d. to 17s. 6d.; Derbyshire hards, 16s. to 17s.; best slacks, 11s. to 12s.; seconds, 9s. 6d. to 10s. 6d.; smalls, 8s. to 9s.

Iron and Steel.—A few large works have only just got into their stride, owing to the considerable amount of stocktaking and the accountancy and clerical work which is involved in the extension of Government control to various concerns in the city. The first step towards fixing selling prices of material has been made in the case of hematite iron. A sliding scale has been adopted, based upon the cost of coal, coke, and ore. Little change can be reported as regards pig-iron, as buying and selling are practically suspended, pending the result of the movement for controlling prices. Values have undergone no alteration since the opening of the new year. Lincolnshire makers are not quoting, though some business has been transacted at 85s. at the furnaces for all qualities. Derbyshire foundry is still quoted round about 80s., while forge is 2s. below that figure. Anxiety is caused among billet users by the gradual depletion of the supplies available. Users think the point of exhaustion cannot be far distant if this depletion continues as it has done for many months. The figure reached for basic material is 12*l.* 10s., and business has been done at 13*l.* in exceptional cases. Delivery is the most serious factor in this branch of trade, and price is regarded almost as a minor factor. American billets are scarce, and are nearly as dear as English. Bessemer is quoted at 14*l.* to 14*l.* 10s., and Siemens at 15*l.* 10s. to 16*l.* Much more material will be required to cater for the new shell factories. New orders for over-seas are numerous, and include springs and buffers for Bombay, steel for Rangoon, Toronto, and Montreal, and orders for files, saws, tools, mining machinery, and plane-irons. The whole cutlery industry is practically under control, every manufacturer being under orders to give first consideration to Army and Navy needs. So much work is in hand that Sheffield cutlery-makers have to send repairs all over the country, and it is feared that there may be something approaching a famine in general household utensils ere long.

THE GERMAN BUNSEN SOCIETY.—The Deutsche Bunsen Gesellschaft held its annual meeting in Berlin on October 18 and 19, 1915. At this meeting Professor W. Nernst presented a note on "The Use of Alternating Current for Wheatstone-Bridge Measurements." We mention the fact because there have been persistent rumours about the death or disappearance of Professor Nernst, who was for some time at the Front. The Society had, however, during the past year, lost several scientists of renown, among them the veteran electrochemist J. W. Hittorf, one of the originators of the dissociation theory, who died in his ninetieth year; Otto Sackur, who was killed at Charlottenburg by an explosion while investigating thermo-dynamics at the lowest obtainable temperatures; Guido Goldschmied, of Vienna; and, further, Professor Heinrichsen, of Charlottenburg; M. von Kügelgen, an electro-chemical engineer, who had worked in recent years in America; and Professor Reinganum, of Freiburg; these three latter were killed at the Front.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Continued shortage of trucks and scarcity of labour is handicapping despatches of pig-iron, and customers complain considerably of inadequate supplies. Deliveries to Scotland are very much in arrear. There is much congestion of shipping at the wharves and in the docks. Values of Cleveland pig-iron are now fairly steady. Demand is good. No. 3 g.m.b. Cleveland pig-iron has this week been sold at 79s. 6d. and 79s. 3d., but has now settled to 79s., at which figure a fair amount of business has been put through. No. 1 is 82s. 6d. to 83s.; No. 4 foundry, 78s. 6d.; No. 4 forge, 78s.; and mottled and white iron each 77s. 6d. All the foregoing quotations are for early delivery.

Hematite Iron.—There is great scarcity of East Coast hematite pig. There is none purchaseable for supply before April next, and some makers report that they have sold the whole of their output to the end of June. Notwithstanding efforts to fix maximum rates at much less, buyers are very keen to place orders at quotations that have ruled for some time past, and now experience considerable difficulty in doing so. For Nos. 1, 2 and 3 delivered over the second quarter of the year 130s. is freely offered, but most sellers ask 135s.

Stocks and Shipments of Pig-Iron.—Stocks of pig-iron are being steadily reduced. Makers have little at their yards, and practically the only stock in existence is the No. 3 Cleveland pig in the public warrant store, which now stands at 109,761 tons, 3285 tons having been withdrawn so far this month. Shipments of pig-iron from the port of Middlesbrough are on only a moderate scale, but are expected to improve. To date this month they amount to 9692 tons, as compared with 19,245 tons to the same date last month and 3820 tons for the corresponding part of January last year.

Coke.—The coke position is difficult, supplies are inadequate, and sellers are reluctant to fall in line with the fixed maximum figure of 28s. for average blast-furnace kinds at the ovens. Sales, however, are understood to have been made at the price, to which, however, must be added 2s. to 2s. 6d. carriage to Middlesbrough. This still leaves the price considerably below what has been paid for some time past for delivering at Tees-side furnaces.

Foreign Ore.—There is little new to report concerning foreign ore. Market quotations are still based on 38s. ex-ship Tees for Rubio of 50 per cent. quality, and freights Bilbao-Middlesbrough are fully 21s. 6d., and likely to be higher. Consumers of ore are receiving more than they need, and with the heavy supplies coming in are accumulating stocks. To date this month imports to the Tees amount to no less than 92,049 tons.

Manufactured Iron and Steel.—Producers of manufactured iron and steel continue fully employed on Government work, and little effort is made to do ordinary commercial business. It is understood that maximum rates have been fixed for steel ship-plates at 11*l.* 10s.; steel ship-angles at 11*l.* 2s. 6d.; and steel joists at 11*l.* 2s. 6d., all net cash on trucks at works, the customary 2½ per cent. discount being discontinued. These prices are higher than have been ruling by 10s. for plates, by 7s. 6d. for angles, and by 2s 6d. for joists, in addition to the discontinuance of the usual discount. Quotations for all other descriptions are strong, and iron bars and iron angles have each been advanced by 10s. per ton. Common iron bars are 13*l.* 10s.; best bars, 13*l.* 17s. 6d.; double best bars, 14*l.* 5s.; treble best bars, 14*l.* 12s. 6d.; iron ship-plates, 11*l.*; iron ship-angles, 13*l.* 10s.; iron ship-rivets, 15*l.* 10s.; steel sheets (singles), 14*l.*; steel sheets (doubles), 14*l.* 5s.; steel strip, 12*l.* 15s.; steel hoops, 13*l.*; heavy steel rails, 11*l.* to 11*l.* 10s.; and steel railway sleepers, 12*l.*—rails and sleepers net, and all other descriptions less 2½ per cent.

Blastfurnacemen's Wages.—The average net selling price of No. 3 Cleveland pig-iron for the last quarter of 1915 has been certified at 67s. 4.16d. per ton, as compared with 64s. 0.54d. for the previous three months, and in accordance with sliding-scale arrangements wages of blastfurnacemen in the North of England are increased by 4 per cent., thus raising wages from 40 per cent. above the standard to 44 per cent above the standard.

Cleveland Miners' Wages.—A meeting of the Cleveland Ironstone Mine-Owners and the miners' representatives was held at Middlesbrough this week to consider the question of wages to be paid to the miners during the ensuing three months. After some discussion it was arranged that wages be advanced at the rate of 3½ per cent., to take effect from the 24th inst.

NOTES FROM THE SOUTH-WEST.

Cardiff.—The steam-coal trade has not shown much change. Since the Christmas holidays a strong tone has prevailed, and confidence has not exhibited any weakening, colliery-owners being fully booked for the next week or two, and users of limited parcels have been able to command a substantial premium on nominal quotations. The best Admiralty large steam coal has been, to some extent, nominal; secondary qualities have made 26s. 6d. to 27s.; best bunker smalls have realised 16s. to 17s.; and cargo smalls have brought 7s. to 11s. per ton. The best household coal has been quoted at 23s. to 24s.; good households have realised 21s. to 22s.; No. 2 Rhondda large has made 22s. to 23s.; and No. 2 smalls have brought 12s. to 13s. per ton. The latest quotation for patent fuel has been 26s. 6d. to 28s. per ton. Special foundry coke has brought 42s. to 45s.; good foundry coke, 38s. to 42s.; and furnace coke, 33s. to 35s. per ton. As regards iron ore, Rubio has been quoted at 36s. to 37s. per ton, upon a basis of 50 per cent. of iron, and charges, including freight, insurance, &c., to Cardiff or Newport.

Western Trade Matters.—Mr. J. A. Findlay, of Abergavenny, district manager for South Wales and the West of England for the London and North-Western Railway, will retire at the close of the present month. Mr. Findlay will be succeeded by Mr. A. Cotton, London and North-Western and Lancashire and Yorkshire Joint goods superintendent at Belfast. Mr. Cotton was chief assistant in the South Wales district from 1889 to 1895. Mr. W. E. Hughes has been appointed manager of Amaral, Sutherland and Co., Limited. An inquiry has been received from the French authorities in Senegal for 6500 tons of patent fuel, to be delivered at Dakar between this month and July. The Egyptian State Railway authorities also require 250,000 tons of Welsh steam-coal 26,000 tons per month in January and February, 25,000 tons per month from February to October inclusive, and 10,000 tons in November. In December last year orders were placed by the Egyptian authorities for 5000 tons of Welsh steam-coal. Freight rates from Cardiff to Alexandria are now 72s. 6d. per ton, so that future Egyptian railway working will clearly be more costly. The shipments of coal from South Wales in the seven years ending with 1915 inclusive were as follows:—1909, 36,052,611 tons; 1910, 35,619,202 tons; 1911, 34,944,044 tons; 1912, 36,268,494 tons; 1913, 41,413,343 tons; 1914, 34,009,476 tons; and 1915, 25,523,736 tons. Patent fuel shipments at Swansea were fairly maintained, coming out last year at 628,234 tons, as compared with 722,564 tons in 1914, 920,698 tons in 1913, and 715,380 tons in 1912. While there was a decreased export movement in 1915, the falling off was less severe than might have been anticipated. Shipments of coal, coke, and patent fuel from Newport last year attained an aggregate of 4,712,003 tons, against 5,608,915 tons in 1914, 6,243,889 tons in 1913, and 5,495,575 tons in 1912. Last year's shipments, foreign, were 3,401,107 tons. Port Talbot shipped 2,185,830 tons of coal last year, against 2,025,902 tons in 1914, 2,478,308 tons in 1913, and 2,146,501 tons in 1912.

OUR RAILS ABROAD.—Last year's rail exports showed a heavy reduction in consequence of the contraction of foreign and colonial railway enterprise occasioned by the great war. The quantity of rails despatched from the United Kingdom during the ten years ending with 1915 inclusive was as annexed:—

Year.	Tons.	Year.	Tons.
1906	460,328	1911	375,290
1907	429,161	1912	411,625
1908	483,521	1913	506,377
1909	530,215	1914	441,606
1910	482,337	1915	242,289

We sent New Zealand 20,491 tons of rails last year, as compared with 17,413 tons in 1914; but this was almost the only exception to general depression. The decline in shipments was still continuing at the end of last year, the exports for December having been only 9937 tons, as compared with 16,315 tons in December, 1914, and 40,744 tons in December, 1913. The deliveries of British rails to Russia last year was 2744 tons, against 9156 tons in 1914; to the Argentine Republic, 1081 tons, against 27,135 tons; to South Africa, 36,342 tons, against 48,375 tons; to British India, 49,441 tons, against 260,334 tons; and to Australia, 67,541 tons, against 129,184 tons. The value of the rails exported last year was 1,791,896*l.*; the corresponding value for 1914 was 2,901,057*l.*, and for 1913 3,457,814*l.*

GERMAN TRADE BARRED IN AUSTRALIA.—Replying to a request from a deputation for further protection for Australian industries, the Prime Minister of the Commonwealth (Mr. Hughes) recently said that the Australian Government would work to increase primary and secondary production in Australia and to prevent German goods coming to Australia in the future. Mr. Hughes said that the Government had nailed its flag to the policy of increased local production and abstention from outside purchasing. "We believe," he added, "that any departure from it would not only be stupid but fatal. By legislation, administration, precept and example we are prepared to do all we can to give effect to our policy. You must leave the details to the Government to look into. Mr. Tudor (the Minister of Customs) will carefully consider the whole question and see to what extent and by what means this policy can be carried out so far as it falls within the sphere of his department. He will then make a recommendation to Cabinet. Already we have cut the tentacles of the German octopus in regard to the metal trade in Australia, and nothing but the determination of those men interested to make this trade grow again will put Germany where she was. Let it be plainly understood that no legislation can control a whole nation determined to set considerations of personal gain against national prosperity and safety. Unless the people support the Government in such circumstances any enactment is only so much waste paper. In regard to the German trade," Mr. Hughes concluded, "we are prepared to do anything and everything that we can to prevent it from coming here, but we must have the support of the people. As to what will happen after the war no one can say. We are only a small portion of the group representing the Allies, and we may not dogmatise now; but if we have the power we will take steps to stop German goods from coming here after the war. In fact, anything more is unnecessary. I would emphasise another point referred to by the speakers. Whatever may be the respective virtues of protection and free trade, we are now faced with circumstances which lift the issue to a higher plane altogether."

ELECTRIFICATION OF THE MANCHESTER TO BURY SECTION OF THE LANCASHIRE AND YORKSHIRE RAILWAY.

(*For Description, see Page* 28.)

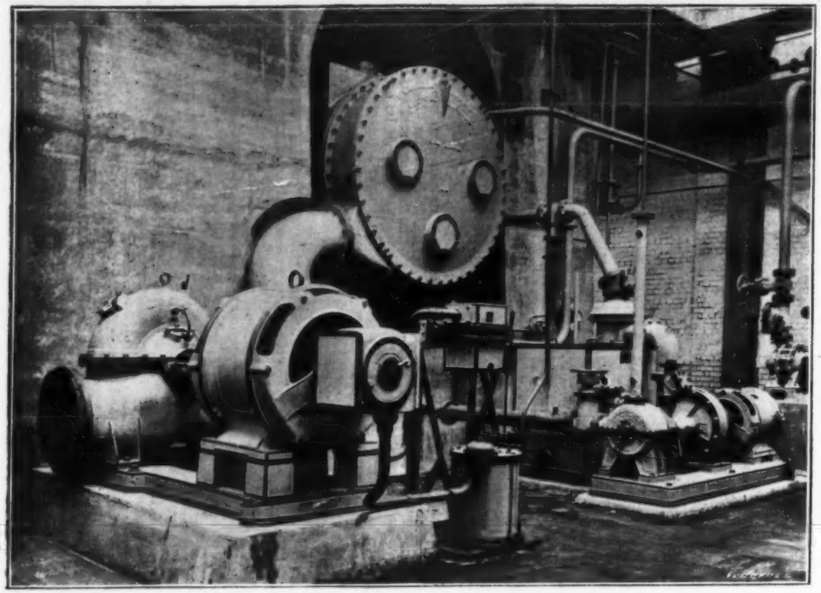


FIG. 19. CONDENSING PLANT FOR 5000-KW. SET.

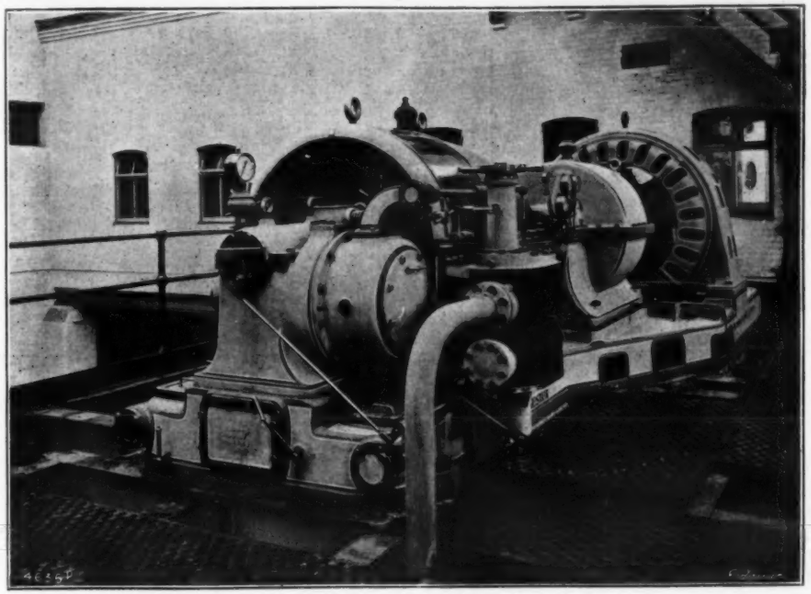


FIG. 20. 500-KW. GEARED TURBO-ALTERNATOR.

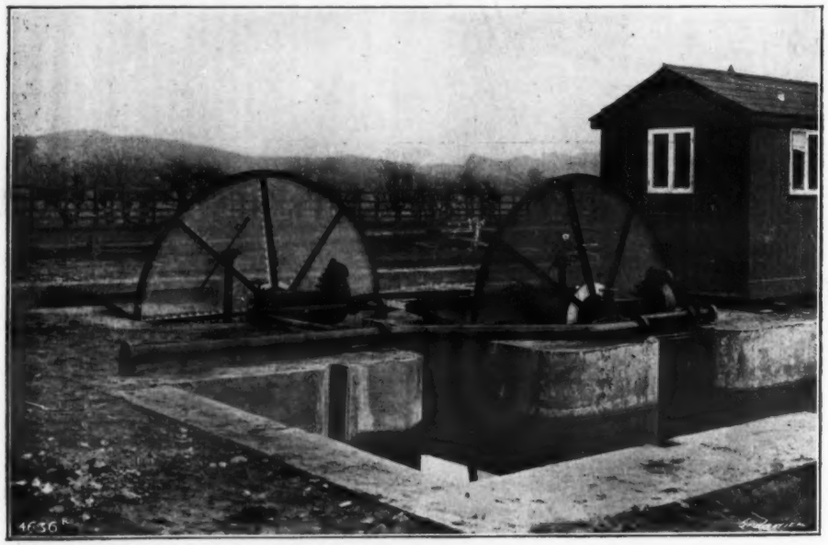


FIG. 21. ROTARY SCREENS.

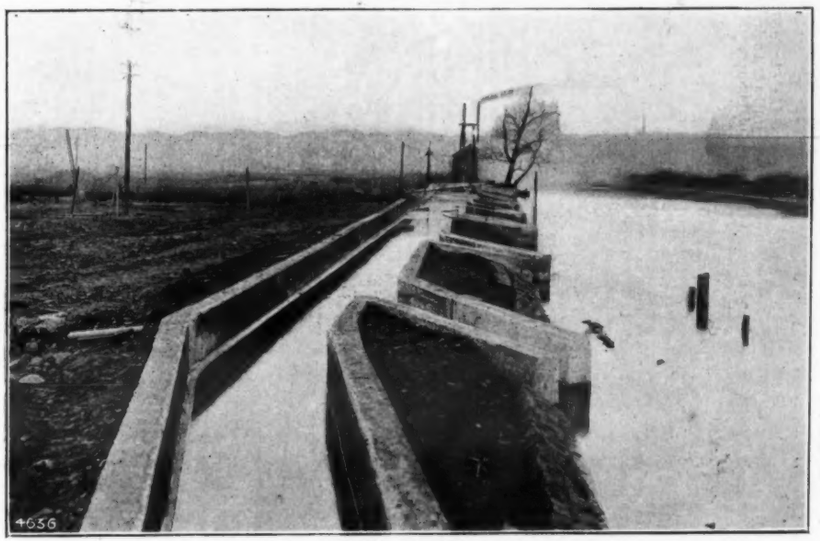
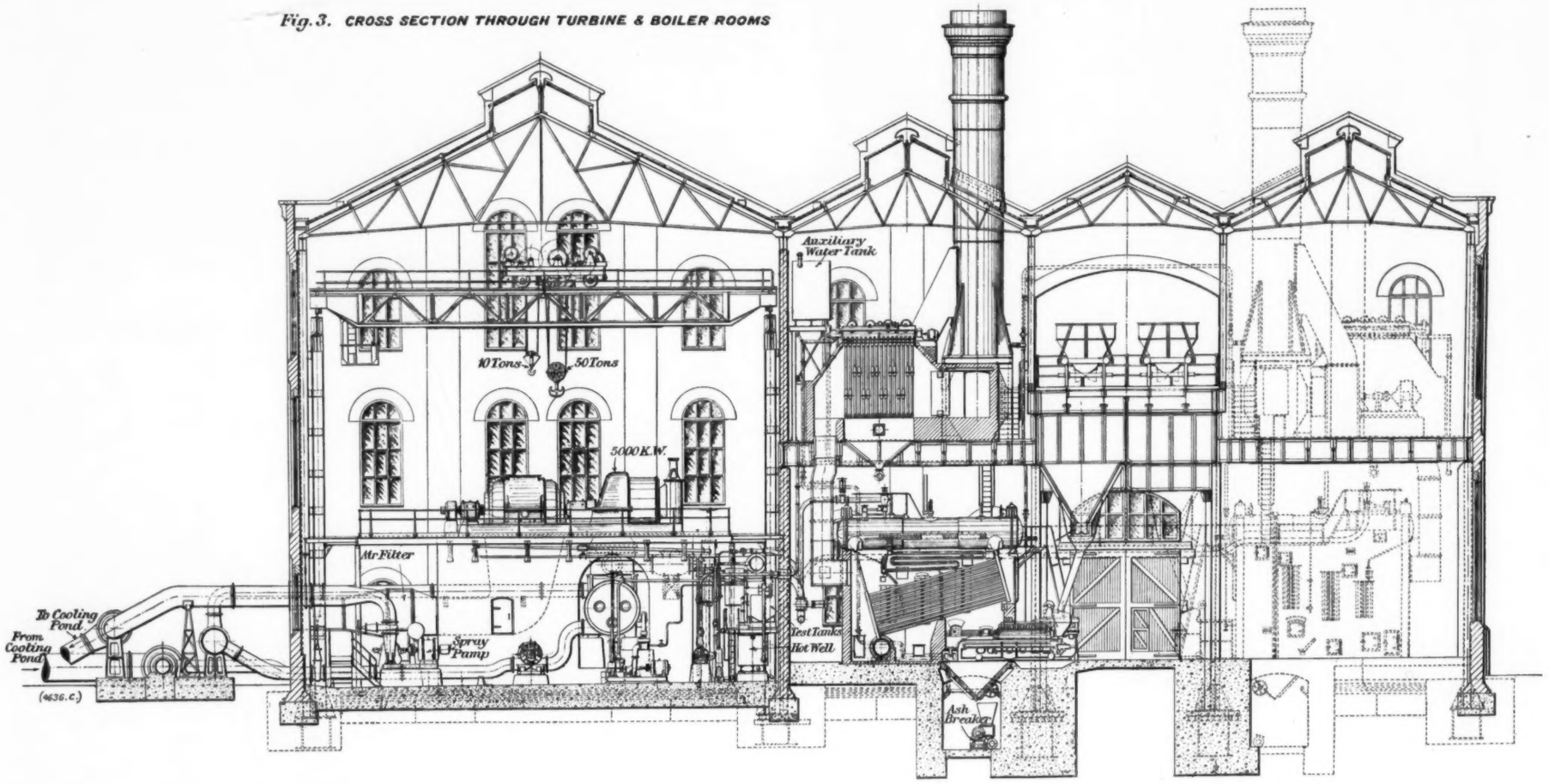


FIG. 22. CONDENSING WATER OUTLETS TO CANAL.

ELECTRIFICATION OF THE MANCHESTER TO BURY SECTION OF THE LANCASHIRE AND YORKSHIRE RAILWAY; THE POWER STATION AT CLIFTON JUNCTION.

(For Description, see Page 28.)

Fig. 3. CROSS SECTION THROUGH TURBINE & BOILER ROOMS



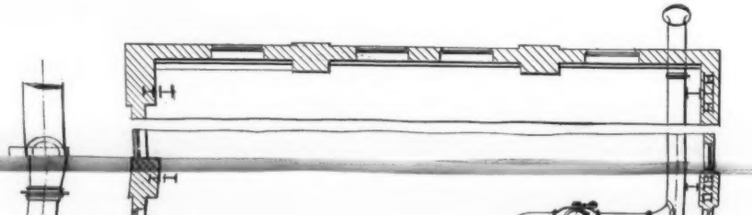
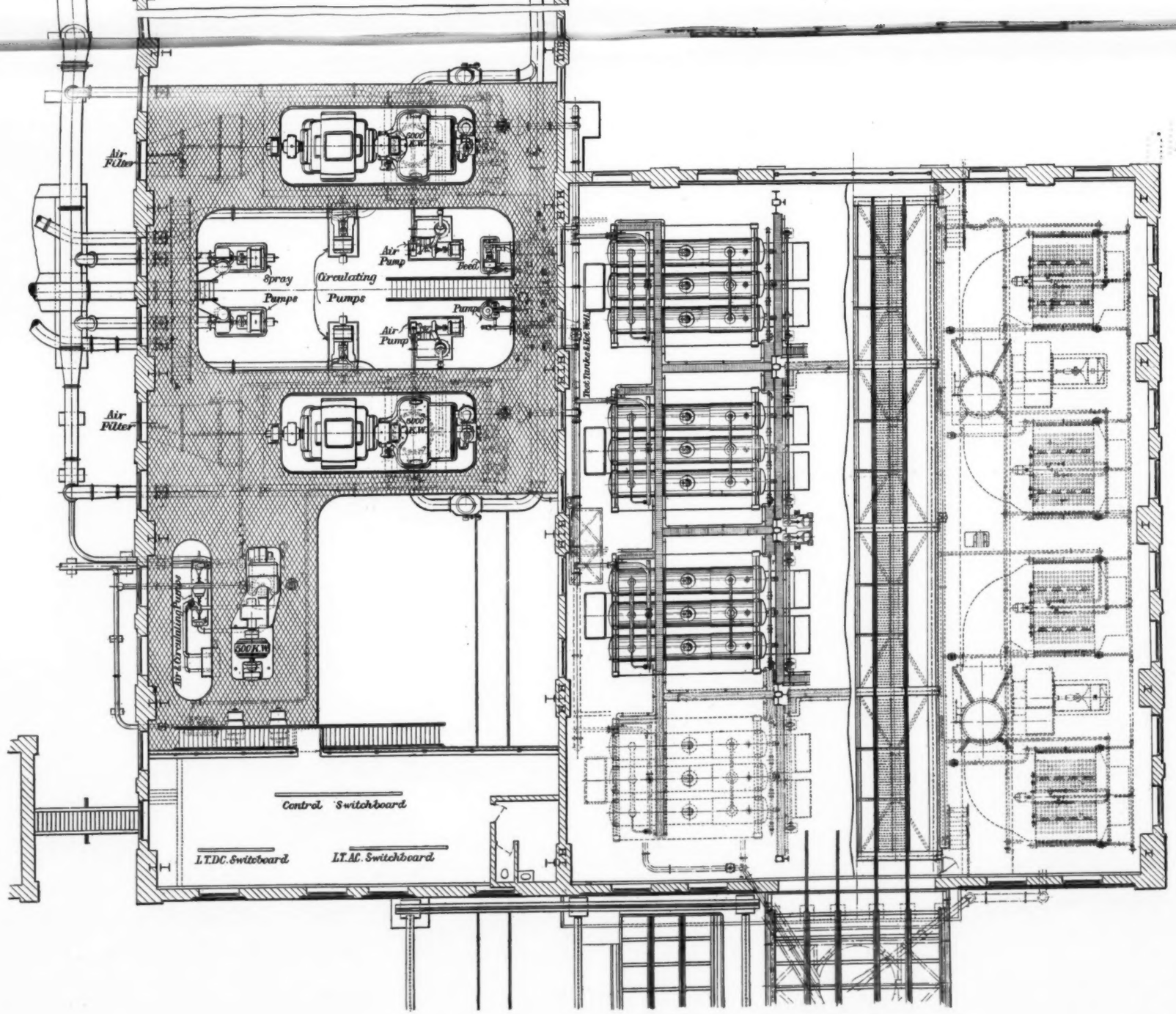


Fig. 4.


Air Filter
Air Filter
Spray Pumps
Circulating Pumps
Air Pump
Air Pump
Feed Pump
Pump
Feed Tanker & Hot Well
Control Switchboard
L.T.D.C. Switchboard
L.T.A.C. Switchboard

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Offices for Publication and Advertisements, 35 and 36, Bedford-street, Strand, London, W.C.

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TELEPHONE NUMBERS—3663 and 8598 GERRARD.

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With a Two-Page Plate of the ELECTRIFICATION OF THE MANCHESTER TO BURY SECTION OF THE LANCASHIRE AND YORKSHIRE RAILWAY: THE POWER-STATION AT CLIFTON JUNCTION.

NOTICES OF MEETINGS.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, January 18, at 8 p.m., at the Royal Society of Arts, John-street, Adelphi, London, W.C. The following paper will be read:—"Oil Storage," by Mr. Herbert Barringer, M. Inst. C.E., M.I. Mech. E., M.I.N.A.

THE NOTTINGHAM SOCIETY OF ENGINEERS.—Wednesday, January 19, at the Welbeck Hotel. The Society will hold a joint meeting with the Association of Mining Electrical Engineers, when Mr. R. A. Sheldon, A.M.I.E.E., will give a paper on "The Use of Electricity in the Conveyance of Coal from the Working Face to the Pit-Head." The chair will be taken at 7.30 p.m., by the President, Mr. W. Ralph Bates, M.I.S.I., and Mr. A. Beeston will occupy the vice-chair. The paper will be illustrated with lantern-slides.

THE ROYAL METEOROLOGICAL SOCIETY.—Wednesday, January 19, at 7.30 p.m., in the Surveyors' Institution, 12, Great George-street, Westminster. Annual general meeting. Proposed alteration of By-Law 14. Election of the Council for 1916. Presentation of the Symons Gold Medal awarded to Dr. C. A. Angot. Address on "Winter Climate of the Eastern Mediterranean," by Major H. G. Lyons, F.R.S., President.

THE ROYAL SOCIETY OF ARTS.—Wednesday, January 19. "The Common Lands of London; the Story of their Preservation," by Mr. Lawrence W. Chubb, secretary of the Commons and Footpaths Preservation Society. With lantern illustrations. The chair will be taken at 4.30 p.m. by Lord Farrer.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Thursday, January 20, at 8 p.m. "The Principles of Modern Printing Telegraphy," by Mr. H. H. Harrison, Associate Member.

THE INSTITUTION OF MINING AND METALLURGY.—Thursday, January 20, at 5.30 p.m., at the Rooms of the Geological Society, Burlington House, London, W. The following papers will be discussed:—"Chinese Mining Legislation," by Mr. William F. Collins, Member. "Taylor's Pulp-Sampler, by Mr. W. H. Trewartha-James, Member.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—Friday, January 21, at 5.30 p.m., a discourse will be delivered by Professor Sir James Dewar, M.A., LL.D., D.Sc. F.R.S., M.R.I. The subject is: "Problems in Capillarity." Afternoon lectures next week at 3 o'clock. Tuesday, January 18, on "The Physiology of Anger and Fear," by Professor Charles S. Sherrington, M.D., LL.D., D.Sc., F.R.S., Fullerian Professor of Physiology, R.I. (Lecture I.). Thursday, January 20, on "The Utilisation of Energy from Coal: The Chemistry and Economics of Coal and its By-Products," by Professor W. A. Bone, D.Sc., Ph.D., F.R.S. (Lecture I.). Saturday, January 22, on "Raphael and Michelangelo," by Mr. Charles J. Holmes, M.A., Director, National Portrait Gallery (Lecture I.).

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, January 21, at 6 p.m., at the Institution of Civil Engineers, Great George-street, Westminster. A paper will be read on "The Flow of Air through Nozzles," by Captain Thomas B. Morley, B.Sc. (of the University of Glasgow), Associate Member.

ENGINEERING.

FRIDAY, JANUARY 14, 1916.

THE BUILDING OF MERCHANT SHIPS.

GREAT significance attaches to the fact that at present there are 264,000 tons less of merchant shipping in process of construction in the United Kingdom than was the case a year ago, while, as compared with normal times, the reduction is nearly 600,000 tons; this, too, notwithstanding that the output has been steadily diminishing, and has for the past quarter only been about one-fifth of the average rate. As is well known, the shipbuilding works of the country have never been so fully employed as during the past year. This has been very largely on war work, as to which nothing can be said. Even a statement of the aggregate output cannot be given; although when this is possible it will be realised that never before have the shipbuilding resources of the country proved so advantageous in the defence of the Empire. The diminution of the merchant fleets of the world from natural causes continues without ceasing, and has been augmented now for eighteen months by the excessive depreciation of such vessels as are engaged on transport duty, as well as, and to a still greater extent, by direct military operations. We have already, in previous articles, urged the increasing importance of the consequent deficiency in tonnage being anticipated, and arrangements made, at as early a date as possible, for progress with ships long since commenced, but arrested, and for the laying down of new vessels. The date for such a resumption of merchant shipbuilding on a large scale rests largely with those responsible for the provision of war material. But behind this decision there are difficult problems which must be faced with resoluteness, and with a desire to do justice, particularly to those firms who have been exerting themselves to the greatest extent in order to meet the demands of the Admiralty.

A study of the volume of work in progress in the respective districts would seem to indicate that where naval work is not extensively done there seems to be a quicker rate of change between the volume of work now and in recent quarterly returns. No doubt this is to a certain extent inevitable, but as there is reduced competition for merchant tonnage, owing to the great demand for new ships and the less number of builders who can undertake the work, the contracts available are being booked on exceptionally favourable terms. Indeed, the rates for new merchant tonnage are much more favourable than those for warship tonnage, because the latter work is placed only with controlled establishments, where, in the first instance, care is exercised to see that the contract prices are not exorbitant, and, in the second place, the amount of excess profit after the execution of the work is limited by the Munitions Act to a very small fraction over that divisible during the years preceding the outbreak of the war. In the few uncontrolled establishments, where such merchant work can be undertaken, there is added to the favourable prices the gain due to the fact that only one-half of the excess profit passes to the Treasury, in addition, of course (as in controlled establishments), to the higher rate of income-tax. Merchant work booked under such unequal conditions must prove more profitable in the immediate future, and, unless some action is taken, gross injustice will be done to shipbuilders who have in their works, at some stage of construction, vessels booked prior to the war, on which progress was stopped at the dictates of the Admiralty, in order to divert all the energies of the establishment to the meeting of the national emergency. There are many such cases, and it is obvious that even were such firms allowed to continue the work on such vessels at an early date, grave loss would still be involved, in view of the higher cost of construction now inevitable as compared with the low contract prices prevailing for new work prior to the outbreak of the war. Some may contend that this is but one of the exigencies of the situation, but this argument is untenable. To begin with, the full extent of the increase in the cost of production was not experienced until some months after the war commenced, and consequently had those firms who are experienced in warship work been permitted to continue operations on merchant ships already booked, these might have been finished at a much less cost than must now be the case. The national emergency demanded that the work should be stopped, in order that the men should be transferred to war material, while at the same time the authorities, to meet labour agitation, enforced the payment of war bonuses on war work. Thus conditions beyond the control of the manufacturer were in every way adversely influencing cost. The effect will be felt by those builders who combine warship and merchant work in proportion to the amount of help they have given during the past eighteen months to the national cause; whereas firms who have done little in the way of warship building will gain enormously. The matter is one of national importance, because it is urgently necessary that nothing should be left undone to ensure the return of a state of equilibrium, especially in sea transport, as soon as peace is achieved.

There is further the case of orders for manufactures of all sorts, but especially for ships booked immediately prior to the outbreak of war, but on which no work was done owing to the absorption of men and manufacturing appliances upon war work. Such orders were taken on a "declining" market; prices were comparatively low. They would, no doubt, have been remunerative had there been no war. Are shipbuilders to be held bound by these contracts? It is obvious that the firms were precluded at the time from executing them owing to national emergency. Now economic conditions have forced up the cost of production, and if these old contracts are to be fulfilled, great loss must result to the shipbuilder unless some Government action is taken. The Moratorium was introduced under somewhat analogous conditions, and provides a precedent for suitable intervention.

The prospect of achieving cheap *post-bellum* freights is not bright when it is remembered that while normally the merchant work in hand is between 1,800,000 tons and 1,900,000 tons, to-day the 420 vessels on the stocks have only a collective tonnage of 1,363,590 tons. This is 173,000 tons less than at the end of last quarter, notwithstanding, as we have already pointed out, that the tonnage launched during the past three months is at a rate of only one-fifth of the normal times. The total on hand, too, is 264,000 tons less than the tonnage twelve months ago, although the output during the period has been very small. It is further shown in Lloyd's returns that of the various districts, Greenock alone shows an increase in merchant tonnage as compared with a year ago, but it is small; the 46 vessels, of 212,954 tons, in

hand show an increase in tonnage of 18,849 tons more than in January of last year, but a decrease of 11,860 tons as compared with September last. The total now is only 37,000 tons less than at the end of 1913. The greatest decrease, on the other hand, is in the Glasgow district, where so much warship work is done. Here the tonnage is little more than half what it was two years ago, while the drop from a year ago is more than 30 per cent., the 63 merchant vessels now on the stocks—many of them having been months there without a single workman being engaged upon them—representing a total of 276,806 tons, or 121,820 tons less than a year ago. At Belfast also there has been a great diminution in merchant work, the total of the 23 vessels now building being 224,150 tons—a decrease of 104,900 tons as compared with the same time a year ago. On the North-East Coast the decrease has not been by any means so great. On the Tyne the decrease, as compared with the end of 1913, is 42,000 tons, and only 6680 tons less than a year ago. There are in course of construction 54 vessels, of 260,546 tons. In the case of the Wear the drop is greater, being 68,000 tons as compared with two years ago, and 23,000 tons as compared with a year ago, the merchant work now on hand including 43 vessels, of 163,639 tons. On the Tees the figures are 31,000 tons down as compared with two years ago, and 11,560 tons down as compared with a year ago, there being 28 vessels, of 60,475 tons, in hand. At Hartlepool, where 11 vessels, of 60,640 tons, are on the stocks, there is a loss of 20,000 tons as compared with two years ago, and of 10,970 tons as compared with a year ago. At Hull the conditions are nearly normal, because here trawlers are built, and these, as is well known, while intended for peace service, are ultimately absorbed in large numbers into the Fleet for mine-sweeping and other auxiliary work. Liverpool, like the Glasgow district, has been greatly influenced by the war demands. Two years ago the merchant work in hand exceeded 64,000 tons, a year ago 32,600 tons, and now it is only 24,487 tons, the latter the measurement of twelve vessels. It may be taken, too, that in the purely merchant shipbuilding districts a greater amount of progress is being made with the merchant work on hand than is the case in districts more largely devoted to warship work.

THE RADIUM-URANIUM RATIO.

ACCORDING to the theory of Rutherford and Soddy, uranium disintegrates into radium at a regular rate, and the masses of radium and uranium occurring in primary ores should therefore bear a definite and constant ratio to one another. The constancy of this ratio was really found in pitchblende, the best known and most valuable uranium ore, consisting practically of the oxide U_3O_8. When afterwards other ores were tested, considerable discrepancies were discovered. Examining autunites (also known as chalcolite, uranium glimmer), which are a complex calcium-uranium phosphate, Ellen Gleditsch observed, in 1909, that these minerals gave on average only 80 per cent. of the radium they should contain, and Soddy himself subsequently found only 44.5 per cent. of the hypothetical radium in one Spanish autunite. In thorianite, on the other hand, more radium was discovered than corresponded to the constant Ra/U ratio. To account for a low percentage of radium, it was suggested that either the minerals might be comparatively too young to give the full radium ratio of old minerals like pitchblende, or that some of the radium in the minerals might have been leached out by water. An excess of radium, on the other hand, might be explained by the assumption that ionium, or some other intermediate disintegration product, had a longer period of decay than had been supposed. The constancy of the ratio has not only scientific importance; for the market value of a radium ore depends upon its percentage of uranium and upon the supposition that each gramme of uranium means a definite, though very small, fraction of a milligramme of radium. Very careful determinations were, therefore, continued by various methods, and the recent investigation of Heimann and Marckwald give the ratio $Ra/U = 3.328 \times 10^{-7}$. They compared eight samples of pitchblende from various parts of the world with the radium solution used by Hönigschmidt in his determination of the atomic weight of radium at the Vienna Institute for Radium Research.

All the ore samples used in these determinations had, however, been rather of small bulk, and the recent extensive and evidently very careful researches of S. C. Lind and C. F. Whittemore (U.S. Bureau of Mines, Technical Paper 88) suggest that many discrepancies disappear when samples weighing, not a few pounds, but weighing or representing tons, are taken, so that a better average is obtained. Their researches concern carnotite, a hydrated vanadate of uranium and potassium frequently occurring, disseminated as a yellow powder, in the sands of Colorado and Utah. Carnotite is at present the most important uranium mineral of the United States. Whilst Boltwood and McCoy credited carnotite with a normal Ra/U ratio, Gleditsch found too small a ratio, and this was confirmed by others, the result being that carnotite fetched on European markets only 70 per cent. of its uranium value, although in a few instances too high radium ratios had also been observed; the figures of Gleditsch ranged from $(2.34 \text{ to } 4.6) \times 10^{-7}$. The carnotite on which Lind and Whittemore experimented contained from 1.5 to 33.5 per cent. of uranium oxide. They did not themselves select their samples, nor did they know the geological history of the ores they were dealing with; but they were provided with "pulp" from car-loads (up to 25 tons) of ores, in addition to original samples of a few pounds weight, and they separately analysed and investigated twenty different specimens by several methods. The first thing in the investigation is the chemical analysis and an exact determination of the uranium percentage, which is difficult, since the separation of uranium and vanadium, especially in the presence of silica and alumina, not to speak of iron, copper, lead, &c., involves elaborate precautions.

When the uranium percentage is known, the ratio Ra/U is determined by the emanation method—*i.e.*, the radium emanation is liberated and quantitatively estimated by the aid of an ionisation chamber and an electroscope. Some emanation is constantly being discharged by radium-bearing minerals; this spontaneous discharge is of the nature of a gas diffusion, and depends upon the compactness of the mineral and the fineness of the powdered sample; the loss of emanation is slow in compact pitchblende, which only loses from 5 to 8 per cent. of its emanation in this way, and rapid in the case of the loose carnotite, whose "emanating power" rises up to 50 per cent. according to Lind and Whittemore. Two methods are available for determining this loss of emanation: the ore is kept in a closed vessel for a month or more, until it has yielded its (maximum) equilibrium quantity of emanation; or the emanation is initially reduced to zero, and subsequently allowed to accumulate for several days, the contents being then calculated by Kolowrat's tables; the latter method was found unsatisfactory. The amount of emanation not spontaneously discharged is liberated by solution; comparative determinations can be based both on the "emanating power" and on the "liberation by solution;" Lind and Whittemore find that it is preferable to apply both the methods, combined or separate, as complementary. Liberation by solution, again, may be effected in various ways. The mineral is boiled with nitric acid, or it is fused either with soda and potash (both as carbonates), or fused or ignited by itself without flux. In the solution method proper the powdered ore is charged into a bulb of very thin glass (up to 1 cm. in diameter), to the sealed neck of which a glass stem is afterwards fused; the bulb is lowered into nitric acid contained in a closed flask, and the stem fused on; after a month the stem is broken off, so that the acid attacks the ore; the acid is boiled, and the gas collecting above it is sucked into and through the ionisation chamber. In addition to this combined method, Lind and Whittemore also determined the emanating power and solution emanation separately.

The disadvantage of the solution method is that any precipitate forming during solution may carry down and adsorb radium. Hence fusion methods are used. By fusing the ore with about five times its mass of alkali carbonates, all emanation then present is liberated. The solidifying mass is considered to be free of emanation, and said not to lose any emanation as long as kept cold; the newly accumulated emanation is afterwards released by stronger heating of the fused mass in a Meker burner. This fusion method did not answer.

Proceeding by the ignition method, the investigators charged the ore into drawn-out tubes of Jena glass, which were left to themselves for about a month; during that time the ore lost nearly half of its emanation which accumulated in the tubes. The one end of the tube was then joined to the outside air, and the other to a micro-drying bulb (containing sulphuric acid) and to the ionisation chamber; when the sealed ends of the tube had been broken off, air was passed through the tube, while the tube itself was heated by a Meker burner until the glass tube collapsed. This direct admission of air would not have been permissible if the ore had contained thorium. The solution and ignition methods gave very concordant results.

The ionisation-chamber of Lind and Whittemore is detached from the electroscope, and is a vertical cylinder, within which a cylindrical electrode is suspended by a brass pin, ending above in a conical tip, from the sealing-wax plug filling the neck. The electroscope, a horizontal cylinder, fits with a short tubular attachment air-tight over the neck of the ionisation-chamber. The wire to which the aluminium foil of the electroscope is attached ends below in a spiral, which fits over the conical tip mentioned, so that electrical connection is established by fixing the electroscope over the ionisation-chamber. As only one determination can be made with every ionisation-chamber in a day, it is advantageous to have several ionisation-chambers for every electroscope; the latter is a more expensive piece of apparatus than the former.

Working in this way and using normal pitchblende as standard substance, Lind and Whittemore found that their average ratio Ra/U was nearly normal, being 101.8 instead of 100 in the case of pitchblende. But the values of separate determinations ranged from 72.4 up to 137.8 per cent., and it resulted that abnormal, too low or too high, values were only found in the case of small samples; yet one big sample yielded 107.5 per cent., whilst all the other big-sample ratios fell within the limits 98.8 to 102.7, several samples giving the correct ratio 100. The investigators hence suggest that there had been some transposition of the radium *in situ*—the ore bed; radium had apparently been washed out from some specimens, and became concentrated in others, but these local differences had been equalised in the large samples. Not having themselves selected their specimen, as we mentioned already, the investigators do not press this argument. But it sounds feasible, especially as most carnotite occurs in arid regions in which rain is rare. The radium percentage can, of course, be estimated directly without determining the uranium contents. Roughly, one may say that 3,000,000 parts of uranium ought to yield 1 part of radium.

PETROLEUM-CRACKING IN THE VAPOUR PHASE.

WE have recently noticed several researches on oil-cracking, designed to increase the proportion of light hydrocarbons such as petrol and gasolene, carried out in big oil works on a fairly large scale. The researches to which we wish to draw attention to-day are of the laboratory type. But they are being conducted on behalf of the Petroleum Division of the United States Bureau of Mines at Pittsburg, in the Chemical Laboratory of Columbia University, New York, and they have an interest of their own, inasmuch as it is not the oils which are, at Pittsburg, submitted to various temperatures and pressures, but their vapours; then the characteristic differences between different petroleums, we are assured, tend to vanish, although the very high temperatures and pressures of other processes are not required. Both these points would be of considerable importance. The leading idea, of making the vapours react, instead of the liquid and vapours, is not new; but we are not aware of its having been practically applied to oils. The idea has its limitations, of course; for a volatilisation, necessarily limited, has to precede the cracking. It also has obvious advantages, however. In ordinary heating of water and steam, *e.g.*, we have to deal with a two-phase system, in which temperature and pressure are mutually functions of one another; when we have one phase only, pressure and temperature may separately be controlled. When in a two-phase system one variable is kept constant, one phase will vanish; when we attempt to heat water at constant atmospheric pressure above 100 deg. Cent., the liquid will disappear, all the water being converted into steam. The case of the very complex

mixture of compounds forming petroleum is not so simple, of course. Yet the analogy holds. When it is desired to heat, for cracking purposes, an oil, the large bulk of which boils below 300 deg., to 850 deg., apparatus capable of resisting enormous pressures are required to retain the liquid phase, and those inconvenient pressures would otherwise be undesirable. It would, on the other hand, not be difficult to pass the vapours through a tube heated to 850 deg., and to keep the pressure at any desired height, even below 1 atmosphere.

The researches in question are in charge of Messrs. W. F. Rittman, Egloff, Towney, and M. C. Whitaker, and an account of the most recent experiments on vapour-cracking is given in the *Journal of Industrial and Chemical Engineering* of November, 1915. For a description of the apparatus used and for other points the reader will have to refer back to pages 383 and 472 of that journal of 1914. The apparatus consists of the following essential parts: oil-feed cup, vaporiser, furnace, Liebig condenser, first receiver, vacuum-pump (or pressure-valve), second receiver, and gas-holder. The furnace is a vertical tube of iron, ½-in. bore, wound outside over a length of 18 in. with five layers of in-chrome wire and asbestos. In the upper portion of the furnace, outside the wound portion, a number of steel balls rest on a perforated steel plate; the oil dripping from the cup wets these balls and is vaporised; the vaporiser therefore forms part of the furnace tube. Pressures ranging from $\frac{1}{30}$ to 30 atmospheres and temperatures up to 850 deg. Cent. were maintained in the furnace proper. About 500 grammes (1 lb.) of oil were passed through the vaporiser and furnace in each run. The quantities of oil recondensed (by recovery) and of gas liberated and carbon remaining in the tube were determined in each run; then followed further distillation and further examination of density, refractive index, viscosity by Engler viscosimeter, and also chemical analysis of the recovered oil and gases. Four kinds of oil were submitted to this treatment, oils from Pennsylvania, Oklahoma, California and Mexico.

The account states that not more than a minimum of attention was given to quantitative relations between the gaseous products. This statement must not be taken too literally. It means that the apparatus, and also the methods applied so far, did not admit of more than rough quantitative estimates. When one knows what products one has to expect, viscosity, refractive index, and specific gravity, tell a good deal; such measurements, confirmed by occasional analyses, were therefore largely relied upon.

The first factor of the results to be considered—the carbon formation—did not agree with the general conclusion above indicated, that the origin and peculiarities of the natural oil counted little in this cracking process; nor was it expected to agree. Carbon is a residual product, and the coking or carbon formation depends to a great extent on the nature and mass of the molecules. The Pennsylvania oil was a kerosene of pure paraffin character, of which 90 per cent. distilled below 250 deg. The Oklahoma oil was a fuel oil, of mixed paraffin and asphaltic base, of which only 22 per cent. came over below 300 deg. The still heavier and more asphaltic California (Kern River) oil gave 17 per cent. of distillate below 300 deg., the lighter Mexican oil yielded 37 per cent. of distillate under the same conditions; but the coke retained much heavy tarry matter. The bulks of the coke deposits obtained were in the order stated.

In other respects the conditions of the treatment proved of more importance than the physical or chemical properties of the original oil. This holds for the percentage of oil recovered; the percentages were greater when working with a vacuum than at atmospheric pressure, and became irregular at higher pressures. The irregularity is partly explained by the difficulties of the determinations; in the case of the Mexican oil, *e.g.*, the coke retained much oil. Commercially, as well as scientifically, much more important is the fact that the gain of gasoline was practically of the same order for all the petroleums, given equal temperature and pressure conditions. By gasoline is understood any hydrocarbon present distilling below 150 deg. The formation of these hydrocarbons increased as the pressure increased to about 24 atmospheres, and increased also with rising temperature, but had a maximum at 500 deg. or 600 deg.; this maximum was about 16 per cent.—*i.e.*, 16 per cent. more of gasoline was found in the cracked oil than had been obtained by distillation of the original oil. Similarly, the production of aromatic hydrocarbons increased as the temperature was raised to about 600 deg.; moderate pressures, 12 to 18 atmospheres, seemed to be best in this case. The yields of aromatic hydrocarbons, benzene, toluene, &c., rose to 13 per cent. All these percentages were probably smaller than they would have been with more perfect analytical methods. But we must repeat that, in the case of the aromatic hydrocarbons, the density test was mainly resorted to. The specific gravities of the paraffin and olefin hydrocarbons, with six and eight carbon atoms, range from 7.0 to 7.2, about, whilst benzene has a density of 0.88, and toluene of 0.87. The densities differ hence sufficiently for rough estimates. From what we have said, however, it will be seen that the favourable temperature and pressure conditions for good yields of both gasoline and aromatic hydrocarbons were fairly the same, and it is not clear, from the experiments so far published, how the process should be conducted so as to give preferentially the one or the other kind of products.

RUSSIA AS A MARKET FOR ENGINEERS.

A SURVEY of the Russian imports during the year 1913 shows not only how vast they are but also the dominant position Germany holds in almost every section. For instance, in the section comprising metals and products within the metal industries, the following table shows the aggregate imports into Russia during the year in question and the share which Germany had of them.

	Aggregate Imports. Roubles.	From Germany. Roubles.
Metals: raw and half-finished products	56,377,822	30,280,845
Copper and alloys, manufactured	10,384,245	9,131,874
Cast iron, manufactured ...	4,340,080	3,236,451
Iron and steel, manufactured (pipes, anchors, nails, &c.)	20,641,901	16,330,760
Tinned and enamelled goods	5,855,016	5,152,417
Iron wire, &c.	2,281,129	1,448,856
Cables, &c.	4,836,275	4,063,417
Needles, guns, &c.	13,767,425	9,414,947
Machines, unenumerated, of iron and steel	36,403,361	28,400,098
Gas and oil-motors	10,390,131	5,716,678
Steam-engines	5,894,885	2,966,945
Pumps—hand fire-engines...	7,696,127	6,733,853
Sewing-machines	9,941,019	5,296,690
Metal-working machines ...	12,787,605	10,658,126
Electrical machines... ...	9,724,948	8,605,365
Agricultural implements ...	24,789,720	9,924,716
Machine parts of cast iron, iron and steel	15,796,213	11,653,331
Instruments, optical, &c. ...	5,169,167	4,419,426
Electrical switches, &c. ...	6,808,319	6,206,244
,, meters	1,492,645	1,455,910
Incandescent metal-wire lamps	4,431,437	3,847,769
Cycles	1,884,541	1,603,801
Parts of carriages, &c. ...	2,135,022	1,558,984
Automobiles for four or more passengers	14,759,379	11,778,865
Goods automobiles, &c. ...	1,453,586	1,162,635
Aggregate	352,669,000	235,930,000

Taking the aggregate of the ten different sections, Germany figures with a total of 652,209,000 roubles, out of total imports amounting to 1,374,032,000 roubles, of which 173,012,000 roubles come from England and 79,092,000 roubles from America. Since 1903 the Russian imports have increased 102 per cent.—from 681,670,000 roubles to the above figures—whilst the share falling to Germany has increased 169 per cent., that of England 53 per cent., and that of America 25 per cent.; Sweden's export to Russia has increased 257 per cent. (in 1913, 16,926,000 roubles), and Denmark's 121 per cent. (in 1913, 12,867,000 roubles). It should also be mentioned that in the section for chemical industry Germany figured with 40,008,421 roubles, or 66 per cent. of the aggregate. The above figures have been extracted from the official Russian statistics and published in a Danish journal.

Denmark, like most other countries, is thinking seriously of working up an increased Russian trade; and an expert committee, representing the Danish iron industry, has paid a visit to Russia and has published a report on the result of its investigations, a report which has attracted some attention outside Denmark. Although the war, and the difficulties it has placed in the way of forwarding goods to Russia, of a necessity have a very serious effect upon trade, and no one under the present circumstances is thinking of buying to stock, yet there is a vast amount of trade to be done. This comprises not only machinery, &c., for military purposes, but also such articles as motors, refrigerating plant, mills, agricultural machinery and implements, and power-engines for industrial installations already commenced, especially in the textile industry. The report emphasises the fact that foreign industry will have great chances in Russia, and that now is the time to do the spade work, in order to get the desired footing in the Russian market.

There is an almost unlimited demand in Russia for almost all products of the iron industry, and people seem agreed that for a very long series of years Russia will be unable herself to cover her requirements, and will have to import a great quantity of goods from abroad. The conditions, however, vary much, both as regards the different classes of goods and the different parts of the vast empire. Generally, it may be said that the finer a machine is, and the more difficult it is to produce, the greater the chance of importing it with advantage on to the Russian market. On account of the duty, heavy and more simple articles are more likely to prove unremunerative, and for some, especially such as are also produced within the country, the duty is simply prohibitive, reaching, or even exceeding, the selling price within Russia of the article in question. Further, it may be stated that, generally speaking, competition is keener in the Western Governments, which are nearer Germany, whilst the chances improve the further East one gets. The report deals with a number of different articles

As regards cast-iron articles for building purposes, this is a class of goods for which a market can only be obtained in the case of special articles, as ordinary cast goods are manufactured within the country and at cheap prices. Heating elements for central heating installations are also made in Russia, and the duty will, no doubt, make it impossible for foreign makers to compete, unless the elements can be supplied in types principally made of rough, not worked, castings, for which the duty is materially lower. There are many Russian firms, partly branches of German concerns, which make heating plants, and this industry, no doubt, has a great future, as it is only in its infancy, and all large new buildings now have central heating installations.

Agricultural machines are principally imported from the United States, from Germany, and from Sweden, while there are several factories in Russia. There may, however, be chances of importing small types, as the American factories have made a speciality of large types. As regards agricultural implements, hoes, forks, axes, &c., they are generally imported without handles; large quantities of these articles are made in Russia, but there is also a considerable import, principally from Sweden and Finland.

Internal-combustion motors are certain of a large demand when constructed for using Russian unrefined petroleum, especially in places such as Moscow, Rostoff, Odessa, Kieff, &c., in spite of there being several Russian factories in this branch. German, Swedish, and Swiss motors are being used in Russia.

For wood-working machines there are several manufactories in the country; still the import is considerable. Machine-tools are for the present in strong demand, and will no doubt also meet with a large sale after the war. German makes have a strong hold on the market, and it remains to be seen how they will fare after the war.

Electrical apparatus and appliances have hitherto been almost exclusively imported from Germany. The articles under this head are generally imported in unassembled parts, on account of the duty. No doubt other countries will exert themselves to secure part of this trade, and a well-known Scandinavian factory in this branch has just had a large Russian catalogue printed.

Of dynamos and electric motors several German and Swedish factories have imported a fair number, but large quantities are made at the Russian manufactories, which have been very fully employed during the war. Light motors run at high speeds are those which meet with the readiest sale. Telephones and telegraph material are imported on a large scale; the Swedish firms particularly enjoy a good standing, and are very liberal in the matter of giving credit. It should also be remem-

bered that there are some large Swedish telephone exchanges in Russia.

Ships' fittings may find a market with the Russian shipyards, especially at Petrograd and on the Black Sea. It should, however, be borne in mind that the Russian shipbuilding industry is on an extremely limited scale, considering the vastness of the country.

The Russians, as already mentioned, much prefer, and are also accustomed to have, prices quoted delivered in Russia, duty paid. In the case of more important machinery, purchases may be made f.o.b. shipping port, and during the war this system has had to be more generally adopted. It is quite customary, also, in dealing with very substantial firms, for a credit of six months, twelve months, or even more, to be allowed. Even the Zemstvo organisations want three to six months' credit. The Russian wholesale merchants and large commercial houses give very long credit, two years or more. Not infrequently, however, payment of one-third of the amount may be obtained on delivery, and as a rule acceptances may be had for the balance of the invoice. When it is a case of agricultural machinery the due dates of such bills are often arranged to fall due immediately after the harvest. During years with unfavourable harvests the seller must be prepared to prolong such bills for another twelve months. The question of credit, on the face of it, calls for a fair amount of caution, although firms dealing with dairy appliances and agricultural machinery have stated that their losses only averaged ¾ to 1 per cent.; but in any case never exceeded 2 per cent. Special caution is recommended in dealing with firms the owners of which are not Russians, particularly in the southern districts of the country. On the other hand, the Government Zemstvos can be safely granted a fairly extensive credit. With regard to the latter the report in question states that the peasants of a district combine in a Zemstvos (an agricultural society), and the Zemstvos within a government are managed by the Government Zemstvos, which acts as buyer of agricultural machinery towards the manufacturer, and as vendor of machines to the local Zemstvos, which again distribute the machines or implements to the different members, who only pay by small instalments. The Government Zemstvos will, as a rule, prefer to buy the machines direct from the manufacturer without any middlemen. It is recommended, at intervals, to forward trade literature, catalogues, &c., in the Russian language to the Government Zemstvos, and in these catalogues ask for an answer in the French or English language if possible. That the Germans have been able to grant such extensive credits is attributed to co-operation with the German-Russian banks. Both Englishmen, Americans, and Swedes are now about to grant longer credits than hitherto allowed. In the matter of large plants and installations a more prompt payment may be obtained; but manufacturers are advised not to press substantial firms too much for quick payment.

Russia, like the other great Powers, is unquestionably most desirous of encouraging and developing her home industries, and very interesting evolutions are sure to be witnessed in this direction, both industrially and financially (the foreign element being much to the fore in Russia in both respects). But, on the other hand, there is such a tremendous scope in Russia, such vast possibilities, that the industries of foreign countries will also have every chance of securing a handsome share in supplying the needs of the vast population of our Ally.

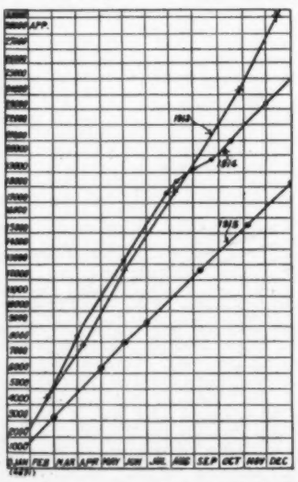
NOTES.

Bridges over Railways.

A point of considerable importance to railway companies was discussed in a case which is reported in last week's number of the *Law Times Reports*. The question was simply this: When a railway company, in the performance of a statutory duty, has erected a bridge to carry a road over its line, to what standard must that bridge be maintained? It is manifest that a brick bridge erected fifty years ago, which might have been amply strong enough to bear the country carts and wagons of the neighbourhood, would soon succumb to the motor-lorries and traction-engines of modern times. The facts were very simple. Under an Act passed in 1862 a railway company was empowered to construct a railway which now forms part of the Great Northern system. At Crouch End a bridge carrying a public highway was built over the line. A contemporary official report spoke of the bridge as "having cast-iron girders," and of its "being substantially built." A little later some mains of the New River Company were carried over the bridge, and additions to the thickness of the substance of the roadway have further added to the dead-weight. The Attorney-General, on the relation of Messrs. Pickford, now sought a declaration to the effect that the railway company were liable so to improve and strengthen the bridge as that it may be sufficient to carry all the traffic that may be reasonably expected to come upon it at the present day. The Court of Appeal have refused to make any such declaration. They relied on a previous case relating to a bridge over a canal, where one member of the House of Lords said that the obligation was to "maintain in its then condition." He went on:—"There is, I think, no principle of construction by which an obligation to maintain, support, and repair a particular fabric can be enlarged into an obligation to reconstruct or rebuild the fabric in such a way that it is materially different in strength, size, or otherwise from the particular fabric the subject of the obligation." In the result, therefore, the railway company was relieved from a heavy burden. The law being as stated, curious results may follow in other parts of the country where railways are under similar liabilities. A highway might be improved out of all recognition, and rendered capable of bearing the very heaviest of motor-lorries; yet traffic along it might be interrupted by a wretched little bridge wholly incapable of bearing anything more formidable than the carts of fifty years ago. Of course, the county council, as highway authority, might in such a case intervene and strengthen the bridge, but the result would be that the railway company, glad to be relieved of a somewhat onerous burden, would confer upon the local authority the privilege of maintaining and repairing the bridge from that time forward.

Patents and the War.

In normal years patent applications are made with great regularity throughout the whole year, as shown in the curve for 1913. This occurred also in 1914 up till the end of July. A rapid change then took place, extending practically over the next two months, after which the relation between time and applications again followed substantially a straight-line law. During 1915, although the total number of applications was considerably less than in 1913 or 1914—the exact numbers being 30,102 in 1913, 24,847 in 1914, and 18,225 in



1915—the curve is a very close approximation to a straight line. This is surprising, having regard to the industrial fluctuations and the changes made by various proclamations relating to patents which have been issued during the year. Thus, on January 7, 1915, the provisions of the proclamations of September, October and November, 1914, were extended; on February 16 the "trading with the enemy" proclamation was made to cover territory in hostile occupation; on June 25 transactions with China, Siam, Persia, and Morocco were limited; on September 14 trading with companies in enemy or hostile occupied countries was forbidden; on October 16 Bulgaria was included in the enemy countries; on November 10 trading with Liberia or Portuguese East Africa was restricted; and on December 7 the whole position was revised. Again, the subjects for which patent applications have been made varied considerably. Thus, comparing quarters in 1913 and 1915, we find the following in a few examples:—

	1913.	1915.
Aerial warfare	5	21
Ammunition	23	111
Chemical processes and apparatus	62	25
Coin-freed apparatus	42	23
Furnaces and kilns	112	50
Internal-combustion engines ...	191	77
Looms	82	44
Machine guns	1	13
Road vehicles	123	59
Small arms	39	106
Torpedoes and mines	18	38

Further, the number of applications made under the International Convention—that is, applications based on foreign patents—has very materially changed, as might be expected; thus, taking at random a certain week in 1913, the *Official Journal of Patents* gives the number of applications open to inspection under the International Convention as 69, whereas in the corresponding week of last year the number was 15.

Carbon-Dioxide Glow-Discharge Lamps.

Our readers will remember that the courtyard of the Savoy Hotel, in London, was illuminated some years ago by Moore tubes, glass tubes, many feet in length, charged with nitrogen under low pressure, through which the alternating discharge was passed from cylindrical electrodes fixed at both ends of the tube. Subsequently Georges Claude, of Paris, charged the tubes with neon—the rare gas which he prepares by his own process on a large scale. These neon lamps had an orange-red glow instead of the pink glow of the nitrogen lamps, which was very effective for illuminating monuments and for advertisement purposes. At a joint meeting of the American Electrochemical Society and the Illuminating Engineering Society, held at New York, in November last, D. McFarlan Moore showed a lamp charged with carbon dioxide gas at low pressure. The mechanism of these lamps was stated to be simpler than that of the former Moore lamps, and the light was described as being white, like sunlight, so that the matching of colours could be carried out in this illumination as well as in daylight. This is an important point, which, it is said, had duly been tested by spectroscopic examination. The simplification of the construction concerns the following point. The old lamps had to be fed with gas or the gas to be replenished through an automatic electromagnetic valve to make up for the gas lost by the absorption of nitrogen by the electrodes or volatilised electrode deposits on walls of the tube. In the case of neon, such a constant replenishing of the gas would be very difficult; by keeping the electrodes cool, this difficulty could be obviated; but neon is a noble gas—*i.e.*, it refuses to associate with other gases, in whose presence the glow is apt to vanish altogether, so that the gas has to be kept very pure [compare ENGINEERING, vol. xcv., page 764, June 6, 1913]. On the other hand, neon requires only one-third of the watts that nitrogen absorbs for giving the same candle-power; but the reddish glow is certainly peculiar. By combining mercury and neon tubes, Claude succeeded in producing a kind of white light, as we mentioned. In the new CO_2 lamp the gas is generated as it is used, in the lamp tube itself. Near each electrode is placed a small bulb, about an inch long, containing calcium carbonate; resistance wires, in shunt to the lamp circuit, are embedded in the carbonate, and the heat liberates CO_2, the process being so regulated that the gas pressure is kept at 0.001 in. of mercury. At this low pressure the discharge is very steady, even with fluctuating volts, and a tube 1 ft. long and ⅞ in. in diameter was said to give more than 200 candles. The lamp looked like a solid bar of white light. It was fitted with a slotted sheet-metal case, provided with a screw in the middle of the case, the screw fitting into a lamp socket. The white colour of the light would strongly recommend this lamp, provided it can be worked economically.

PUMPING MACHINERY.

Some highly interesting figures, showing the reduction in the costs of pumping by steam-power since the days of Newcomen, were set forth in the

LIST OF PUMPS INSTALLED BY THE RAND WATER BOARD FROM 1907 TO DATE.

Position.	Date of Erection.	Description.	Number of Stages.	Head in Feet	Gallons per Minute.	How Driven.	Maker of Pump.	Specified Efficiency.			Efficiency of Test.			Cost of Motor and Pump.		Pump Horse-Power.	Cost per Pump Horse-Power.
								Motor	Pump	Combined.	Motor	Pump	Combined				
								p.c.	p.c.	p.c.	p.c.	p.c.	p.c.	£	s.		£
Zwartkopjes—																	
Pump No. 4	1907	Inverted vertical marine type	—	900	1389	Steam	Hathorn, Davy and Co.	11.5 lb. steam per P.H.P. hour			11.220 lb. steam per P.H.P. hour			10,179	0	380	26.786
Pump No. 5	1907	Ditto	—	900	1389	Ditto	Ditto	Ditto			11.461 lb. steam per P.H.P. hour			10,179	0	380	26.786
Pump No. 2	1908	Ditto	—	900	1389	Ditto	Ditto	Ditto			10.782 lb. steam per P.H.P. hour			10,179	0	380	26.788
Pump No. 3	1908	Ditto	—	900	1389	Ditto	Ditto	Ditto			11.541 lb. steam per P.H.P. hour			10,179	0	380	26.786
Zuurbekom—																	
Pump No. 1	1912	Centrifugal	3	700	1736	Electrically, 3-phase	Weise and Monski	93.0	75.2	69.9	Pumps and motors tested at makers by Board's Inspector		—	1,235	0	368	3.356
Pump No. 2	1912	Ditto	3	700	1736	Ditto	Ditto	93.0	75.2	69.9			—	1,235	0	368	3.356
Pump No. 3	1912	Ditto	4	1150	1736	Ditto	Ditto	93.5	75.2	70.3			—	1,612	10	605	2.665
Pump No. 4	1912	Ditto	4	1150	1736	Ditto	Rees Roturbo	93.5	76.0	71.1			—	1,615	0	605	2.669
Springs—																	
Pump No. 1	1912	Three-Throw	—	600	521	Ditto	Ernest Scott & Mountain	89.0	85.4	76.0	Ditto		75.5	1,352	0	95	14.232
Pump No. 2	1912	Ditto	—	600	521	Ditto	Ditto	89.0	85.4	76.0			75.0	1,352	0	96	14.232
Pump No. 3	1912	Ditto	—	600	521	Ditto	Ditto	89.0	85.4	76.0			76.0	1,352	0	96	14.232
Pump No. 4	Feb., 1912	Centrifugal	5	600	521	Ditto	Pulsometer Pump Co.	—	78.0	—			—	344	0	95	3.621
Village Main Reef Station—																	
Pump A..	1908	Triple expansion	H. lift	300	1466	Steam	Worthington Pump Co.	12.2 lb. steam per P.H.P. hour			13.586 lb. steam per H.P. hour			7,588	0	215	35.3
			L. lift	80	2833	Ditto	Ditto										
Pump B..	1908	Duplex	H. lift	300	1466	Ditto	Ditto	Ditto			12.912 lb. steam per H.P. hour			7,588	0	221	34.3
			L. lift	80	2833	Ditto	Ditto										
Village Main Reef Station	Nov., 1912	Centrifugal	1	300	2083	Steam-Turbine	Rees Roturbo	—	78.0	69.0			—	2,680	0	189	14.180*
End-street, Johannesburg	June, 1913	Ditto	2	267	2083	Electrically, 3-phase	Sulzer	92.5	75.4	69.75	Pumps and motors tested at makers by Board's Inspector		—	730	10	168	4.289
Zuurbekom—																	
Shaft No. 4	Dec., 1914	Ditto Vertical spindle	1	225	1562	,, 3-phase	Mather and Platt	91.0	75.0	68.25			—	1120	0	106	10.660
Shaft No. 6	,, 1914	Ditto	2 Single	155	3472	Ditto	Sulzer	93.0	76.0	70.68			—	1360	10	165	8.245†

* Steam consumption, 19.55 lb. per pump-horse-power hour. † Two single stages, arranged in parallel.

late Mr. W. B. Bryan's Thomas Hawksley lecture. A pumping-engine erected at Philadelphia in 1801 had, it was stated, a coal consumption of about 21 lb. per pump-horse-power hour. This was superseded in 1815 by an engine built by Boulton and Watt, which consumed about 10½ lb. of coal per pump-horse-power hour. This figure was, of course, still extremely high, and was greatly reduced by the introduction of the Cornish engine. Indeed, an engine of this type, erected at Fowey in 1845, was claimed to yield 1 pump horse-power for 1.45 lb. of coal, but this figure can hardly be accepted. Nevertheless, the Cornish cycle was undoubtedly a very efficient one, and further advances in fuel economy have only been effected slowly and with much effort.

Some interesting data as to figures recorded with modern plants are to be found in the presidential address to the South African Association of Engineers, delivered in July last by Mr. W. Ingham, the Chief Engineer to the Rand Water Board. These figures are the more valuable in that they are in many cases accompanied by particulars as to the cost of installation, which in some cases has been so high that Mr. Ingham questions whether the saving in fuel costs has not been purchased too dearly. The best result yet recorded was obtained in the official trials of the triple-expansion three-throw pumping-engines erected at the Zwartkopjes station of the Rand Water Board by Messrs. Hathorn, Davey and Co., of Leeds. The engine had the advantage, which is great in the case of a reciprocating engine, of working against the high head of 960 ft., and the maximum output against this head was 100,000 gallons per hour. The initial steam pressure was 180 lb. per sq. in., and the superheat was 120 deg. Fahr. The consumption was only 10.78 lb. of steam per pump horse-power per hour, the mechanical efficiency of the plant being 93.14 per cent. The cost of the installation, including buildings, was, however, 95.9*l.* per pump horse-power installed. Comparative figures for other pumping plants erected by the Board are given in the table above.

The costs given in the above table, it should be borne in mind, do not include the complete costs, since the reciprocating plants occupy so much more space and require such substantial foundations that the relative value of the centrifugal system is substantially augmented, and, in fact, Mr. Ingham expresses the view that steam-turbines coupled to centrifugal pumps will ultimately drive the reciprocating pump out of the market for surface pumping. As showing the saving in space and cost effected by the adoption of the centrifugal pump, Mr. Ingham compares the electrically-driven plants at the Springs pumping-station. At this station there are three sets of three-throw reciprocating pumps and one centrifugal pumping plant, all working under identical conditions. The first cost of the three-throw pumps per horse-power was four times that of the centrifugal. In addition, the building to accommodate the three reciprocating sets had a capacity of 30,240 cub. ft. and a floor area of 1890 sq. ft. The equivalent figures for centrifugal sets are 11,760 cub. ft. and 735 sq. ft. respectively. The combined efficiency of the reciprocating sets was 76 per cent., and that of the centrifugals, 69 per cent.

Possible competitors with the turbine-driven centrifugal are the Diesel engine and the Humphrey pump. The former is very efficient, and Mr. Ingham states that at the Whitton pumping-station, Ipswich, the cost (fuel only) of raising water by Diesel-driven centrifugals is ¼d. per 1000 gallons lifted 100 ft., with crude oil at 3*l.* 13*s.* per ton. This plant superseded a steam-driven station, at which, with coal at 21*s.* per ton, the cost of pumping per million gallons was 34*s.*; with the Diesel this figure was reduced to 25*s.* The initial cost of the Diesel station was about 33*l.* per brake horse-power installed. The Humphrey pump holds the record for pumping costs where the lift is low, and Mr. Ingham states that he understands that a high-lift pattern will soon be available.

LITERATURE.

Telegraphy. By the late Sir W. H. PREECE, K.C.B., F.R.S., and Sir J. SIVEWRIGHT, M.A., K.C.M.G. Revised and partly re-written by W. LLEWELLYN PREECE, M. Inst. C.E. New Edition. Longmans, Green and Co. [Price 7*s.* 6*d.* net.]

THIS work, which, on its first appearance in 1876, might have been regarded as an authoritative description of the methods employed in the British Post Office, has undergone so many changes that its present form constitutes practically a new treatise. Additions and omissions have both contributed to this result. Research in the laboratory has suggested new lines for commercial development, and the small beginnings of what were destined to be giant growths could be conveniently included in successive editions; but as ingenuity and experience extended these new branches, the book grew to an unwieldy length in trying to do justice to these advances, and late developments had to find a more convenient home elsewhere. In this edition the division of submarine telegraphy has had to be dropped. Mr. Llewellyn Preece, who is responsible for this revision, justifies this elimination on the ground that submarine telegraphy has separated itself from telegraphic engineering. Those who are engaged in land telegraphy are entirely divorced from the submarine branch, and need quite other instruction. River and coast cables, forming, as they may do, necessary links in land lines, are alone treated. On the other hand, new chapters have been added on Secondary Batteries, on the Baudot System, now attracting much attention, and on Comparative Results obtainable with various high-speed telegraph systems. Other sections which will soon have to disappear are those on Telephony and Wireless Telegraphy. They fall below the level attained in other directions. The complications introduced into large telephone exchanges, or, rather, the devices necessary to avoid complications, cannot be adequately dealt with in the small space allotted to this section, while the expansions of the systems of wireless methods demand that more comprehensive treatment that is only possible in technical treatises solely devoted to this subject. The author aims at providing real and practical assistance within definite limits. This is not an academical treatise; it enters into minute details in some directions, and gives sufficient information for those who have to construct telegraphic apparatus for small centres or sparsely-populated countries.

It is well that this practical scope should be understood. There is a distinct line of demarcation separating the physicist from the engineer. The work of the former is to discover new outlets for mechanical science; it is the duty of the latter to apply the new facts and new truths to the service of mankind. The function of the one is research, of the other utility. It is entirely to the engineer that this book is addressed. The electrical engineer has not to seek out his facts for himself. By the method in which modern science is pursued, and the growth of technical education, he can enter into other men's labours, and turn them to profitable account with the least expenditure of energy. For him are necessary close observation and careful attention to the requirements of the working. The exercise of these qualities is everywhere insisted upon, and nowhere more particularly than in the chapters relating to construction. The instruments for testing, and the methods of locating faults, are again matters of high practical importance that an engineer working in some distant colony, with little expert assistance, would highly appreciate.

With regard to the new matter introduced into this volume, the more interesting relates to the description of the Baudot system—a multiplex system of transmitting signals designed to secure the more economic working of the line. In this system the Morse alphabet is discarded, and each letter is represented by five current impulses, some of which are positive and some negative. The mechanical arrangements of both the transmitting and receiving apparatus are necessarily complicated, and the diagrams need to be followed with some patience. The instrument has the advantage of

automatically recording the message in Roman characters on a flowing tape. To obtain the full efficiency of the method the number of operators required is large, and therefore the working is costly. The normal speed of working is thirty words per minute per operator. A line over which the Baudot sextuple duplex is worked can transmit 360 words a minute, requiring a staff of twelve operators. But no perforated slip is needed at the transmitting end, as in some of the so-called automatic systems.

The necessity of employing many operators naturally raises the question of the most economic system in use, and the most judicious selection of apparatus to meet actual and prospective traffic. Six systems of telegraphy are described here, the six that are held in the highest esteem in this country. These are the Duplex, the Quadruplex, the Baudot, the Wheatstone automatic, the Gell-Wheatstone, and the Creed-Wheatstone, the two last needing mechanical perforators. The uncertainties in the problem are the amount of traffic to be handled, and the wages paid to different classes of expert assistants. It is possible to estimate with close approximation the probable initial outlay, the cost of maintenance, the number of staff per shift, and to express this last in terms of trained operators of the highest class, the ratio of wages in different classes being fairly well maintained in different countries. For a line over which a traffic of thirty words a minute may be anticipated the Duplex and the Baudot Simplex would be competent, and the least costly installation. But though the outlay on the Baudot is 1000*l*., as opposed to only 120*l*. in in the case of the Duplex, the economical advantage rests with the Baudot. If the traffic is increased to fifty words a minute, the Quadruplex and the Gell-Wheatstone may compete with the fore-mentioned systems. The number of operators must be doubled, though the work is only increased some 70 per cent., and the advantage lies with the Gell-Wheatstone mainly on account of its smaller initial outlay—400*l*., as against 1200*l*. for the Baudot. Increasing the traffic to 100 words a minute, by which addition we again have four competing systems, the prize for economy is adjudged to the Wheatstone-Creed, for its greater initial cost (2100*l*.) is more than compensated by the diminished number of operators required. While the Wheatstone Duplex and the Baudot each need a staff of eighteen operators per shift, the Wheatstone-Creed can be worked with ten. But a Baudot six-arm Simplex, costing about 1600*l*., would deal with a traffic of 180 words a minute, employing fourteen men. Under such circumstances the Baudot would run the Wheatstone-Creed very close, and the choice would probably be made on other than pecuniary grounds. Of course, greater speeds than this can be accomplished. Under pressure it is possible to transmit 400 words a minute, and since under Morse signalling the most expert operator cannot send more than forty words per minute, it is easy to see how enormously the efficiency of the whole line is increased by adopting automatic methods. As a rule, the public fail to appreciate the vast amount of intelligence disseminated over the country by telegraphic means. The author states that sometimes a million words are sent on a single night, or, say, the contents of ten novels of average length.

Submarines; Their Mechanism and Operation. By FREDERICK A. TALBOT. London: William Heinemann. [Price 3s. 6d. net.]

THE author, in previous volumes on kindred subjects, has shown remarkable gifts of exposition after judiciously selecting and industriously studying sources of primary knowledge. This addition to his series of quasi-technical treatises, which the war has made inevitable, is in no sense inferior to its predecessors. Such works serve a useful purpose for general enlightenment, but must never be accepted by the student desirous of mastering any branch of engineering. Nor does the author of this work seek for such readers. He makes that clear in his preface. But this is no excuse for misleading technical statements, which should be avoided even in a work for the general reader. On page 54, for instance, it is said:—"If high-speed gasolene-engines are used, the employment of reducing gear is essential, so as to bring the engine speed down to that required for the propellers"! The definition of the difference between the submersible and submarine is wrongly, if vaguely, expressed, the author comforting himself with the reflection that the differences are merely of technical import (page 34). Again, it is stated that ingenious efforts were, and are being, made to utilise "a closed system" of steam-engine for operating the propellers when the vessel is submerged (page 62). It appears, on page 67, that the pressure due to fuel combustion within the Diesel engine forces the piston down with "increasing" velocity. Other such inaccuracies could be mentioned. It is a pity that a book generally so worthy of commendation should not have been revised by someone technically conversant with the subject.

The evolution of the submarine and the present, or rather ante-bellum, stage of progress in design are described in quite an attractive form. The mechanism, equipment, and armament are explained, and to the reader there is conveyed a vivid idea of operations on the surface and submerged. The fleets of all the Powers are dealt with; but it is inevitable that nothing could be written as to recent developments. There is thus little that is new. Indeed, of the thirty-two page engravings at least eighteen have already appeared in ENGINEERING, twelve of them in our issue of as long ago as November 17, 1911. The sections of submarines on pages 200 and 202 have been copied from the same issue, without acknowledgment.

The author ventures little on prediction. In his last chapter on the limitation and the future of the submarine he says that "generally speaking, the submarine, as a fighting machine, has excelled the most sanguine anticipations of those who were in a position to know" (page 253). And yet later he seems to prove the contrary. "So far as present experience has carried the subject, the underwater naval vessel is restricted to one sphere of activity—raiding. Here, again, there are limitations" (page 258). "As the war drags along, the Germans are realising that the submarine, like the much-vaunted airship, is somewhat in the character of a faith cure" (page 260). "There is every indication that a complete means of rendering the submarine impotent will be perfected before the war has run its length, and this circumstance has served to extend additional support to the theory that the submarine, as it is known to-day, will be superseded" (page 262). But in what follows the author shows that he is not in possession of the facts and their bearing on the potentialities of the future.

BOOKS RECEIVED.

United States Geological Survey. Professional Papers. No. 95 B: *Eocene Glacial Deposits in South-Western Colorado.* By WALLACE W. ATWOOD. No. 95 C.: *Relation of the Cretacious Formations to the Rocky Mountains in Colorado and New Mexico.* By WILLIS T. LEE. Washington: Government Printing Office.

United States Department of Commerce. Monthly Summary of the Foreign Commerce of the United States. No. 10: April, 1915. No. 11: May, 1915. Washington: Government Printing Office.

United States Department of Commerce. Circular of the Bureau of Standards. S. W. STRATTON, Director. No. 20: *Electrical Measurements.* Washington: Government Printing Office.

United States Department of Commerce. Scientific Papers of the Bureau of Standards. S. W. STRATTON, Director. No. 246: *Methods of Measuring Inductances of Low-Resistance Standards.* By FRANK WENNER, ERNEST WEIBEL, and F. B. SILSBEE. Washington: Government Printing Office.

United States Geological Survey. Monographs. Vol. LIII.: *The Pleistocene of Indiana and Michigan and the History of the Great Lakes.* By FRANK LEVERETT and FRANK B. TAYLOR. Washington: Government Printing Office.

The Elements of Surveying and Geodesy. By WILLIAM CHARLES POPPLEWELL, M.Sc. London, New York, Bombay, Calcutta, and Madras: Longmans, Green and Co. [Price 7s. 6d. net.]

Table of Compound Interest at ¼ per Cent. and of Antilogarithms to Base 1.00125, whereby any Compound Interest Function may be Calculated, and the Logarithm and Antilogarithm to 60 Figures or Less, of any Number of 60 Figures or Less, to any Base of 60 Figures or Less may be Found. By JOSEPH J. STUCKEY, M.A., A.I.A. London: George Allen and Unwin, Limited, Ruskin House, Museum-street, W.C. [Price 21s. net.]

The Boy Electrician. By ALFRED P. MORGAN. London: Duckworth and Co., 3, Henrietta-street, Covent Garden, W.C. [Price 5s. net.]

First Aid in the Laboratory and Workshop. By ARTHUR A. ELDRIDGE, B.Sc., and H. VINCENT A. BRISCOE, D.Sc. With a *Foreword* by Surgeon-General Sir ALFRED KEOGH, K.C.B. London: Edward Arnold. [Price 1s. net.]

The Testing of Machine-Tools. By GEORGE W. PURLEY, Wh. Ex. With 110 illustrations. London: Scott, Greenwood and Son. [Price 4s. net.]

YEAR-BOOKS AND ANNUALS.

Hazell's Annual, 1916.—This annual for the coming year, which is issued at the price of 3s. 6d. net by Messrs. Hazell, Watson and Viney, Limited, 52, Long Acre, London, W.C., has now appeared. It is edited by Mr. T. A. Ingram, M.A., LL.D. It gives the *personnel* of Government offices and important public bodies, a complete list of the recipients of the Victoria Cross, a Roll of Honour, information concerning the war, data on the United Kingdom, the British Colonies and Dominions, and on foreign countries. It appeals to a very wide circle.

The "Mechanical World" Pocket Diary and Year-Book, 1916.—This year-book, which is published, as usual, at the price of 6d. net, in Manchester, by Messrs. Emmott and Co., Limited, whose London offices are 20, Bedford-street, W.C., gives in a very small and handy compass a vast amount of useful information on steam-engines, turbines, Diesel engines, &c. It contains also a large number of mathematical data, and is completed by a diary for the year.

The "Mechanical World" Electrical Pocket-Book, 1916.—This is a companion to the former year-book in regard to electrical subjects. It is issued by the same publishers, also at the price of 6d. net. It deals with the generation of current and all its manifold applications.

The South Wales Coal Annual, 1916.—This annual is edited by Messrs. Joseph Davies and C. P. Hailey, and is published at the price of 7s. 6d. net, by the Business Statistics Company, Limited, Baltic House, Cardiff. It gives illustrated information relating to the firm of T. Beynon and Co., Limited; prices of coal at different periods of 1914 and 1915; data on legislation affecting coal; forms of bills of lading, charters, &c.; statistical data; output, export, &c., concerning Welsh coal, and so forth.

The British Dominions' Year-Book, 1916.—This useful year-book, edited by Messrs. Edward Salmon, F.R.C.I., and James Worsfold, F.C.I.S., like its predecessor entitled "War Facts and Figures," can be obtained from the British Dominions' General Insurance Company, Limited, 1, Royal Exchange Avenue, London, E.C. It gives numerous statistics and a large series of interesting articles, among which we may mention "The First Year of the War," by E. Charles Vivian; "The Imperial Navy," by Fred T. Jane; "The Cost of the War—the First Year," by Edgar Crammond, F.S.S.; several articles on the part taken in the war by the Dominions, including one by Sir Leo Chiozza Money, M.P., entitled "A Business-like Empire, its Development and Conservation," which emphasises the straits to which the British Empire has been put through lack of business-like methods, and points the way out of the difficulties. Other articles deal with the "Economical Outlook for Germany," with "Revelations and Devices of the War." The book contains a number of good maps and illustrations.

The Guide to South and East Africa.—This guide for the present year, the twenty-second edition, is edited by Mr. A. S. Brown, F.R.M.S., and Mr. G. G. Brown, F.R.G.S., and is issued for the Union-Castle Mail Steamship Company, Limited, like the preceding editions, at the price of 1s., by Messrs. Sampson Low, Marston and Co., Limited, London. It contains a large number of very neat coloured maps, plans, and diagrams, and a vast amount of interesting information on South and East Africa. The guide has been entirely re-arranged, and the index has been re-cast. Data concerning game, sport, and overland expeditions have been grouped under a new section entitled "Exploration and Sport." The sections on South-West Africa (formerly German S.W.A.), on Portuguese Angolaland and Katanga (Belgian Congo) have been re-written and enlarged.

The Colliery Manager's Pocket-Book.—We have received a copy of this pocket-book, almanack and diary for 1916, the forty-seventh year of publication. It gives about 450 pages of useful data on the mining progress during the past year, also in regard to electric signalling in collieries, the coal-dust question, coal-mining organisation, &c.; coal-mining statistics; detailed information on coal-getting in all its various aspects, on safety and sanitary devices and appliances, &c. A map shows the inspection districts of the United Kingdom. It is edited by Mr. Herbert Greenwell, F.S.S., Assoc. M.I.M.E., and is published at the price of 2s. net by the Colliery Guardian Company, Limited, 30 and 31, Furnival-street, Holborn, London, E.C.

Business Prospects Year-Book.—This interesting year-book analyses the situation for the past year of the coal, iron, copper, tin, tin-plate, oil, money, shipping, wheat, cotton and rubber markets in the

United Kingdom, and gives in a few lines what are the prospects of the trade in these various commodities for the present year. There are detailed statistics for each of the commodities reviewed, and for each source of supply; the book also deals with the situation of the various markets both in the allied and in the enemy countries. The book will prove of great value for reference purposes. It is edited by Messrs. Joseph Davies and C. P. Hailey, and is published at the price of 10s. net by the Business Statistics Company, Limited, Baltic House, Cardiff. The London publishers are *The Financial Times*, 72, Coleman-street, E.C.

The Electrical Engineer's Diary.—We have received a copy of this diary, which is edited by Mr. J. H. Johnson, M.I.E.E, and is issued at the price of 3s. 6d. by Messrs. S. Davis and Co., 30 and 31, St. Swithin's-lane, London, E.C. It measures 11 in. by 9 in., and gives in the first portion over 300 pages of information on current generation and distribution for all classes of power uses and for lighting; the second portion forms the diary, with interleaved blotting-sheets. It forms a useful desk companion.

Almanacks, Calendars, &c.—We have received a monthly tear-off calendar from Messrs. H. W. Ward and Co., Limited, machine-tool manufacturers, Lionel-street, Birmingham; one from Messrs. R. Y. Pickering and Co., Limited, railway rolling-stock builders, Wishaw, near Glasgow; one from Messrs. Unwin Brothers, printers, 27, Pilgrim-street, Ludgate Hill, E.C.; a very neat monthly desk calendar from Messrs. Stewarts and Lloyds, Limited, the well-known tube manufacturers, Broad-street Chambers, Birmingham, and 41, Oswald-street, Glasgow; two artistic monthly tear-off calendars from Messrs. J. G. Fish, Hall and Co., stationers and printers, 11, Bishop's-court, Chancery-lane, London, W.C.; also a treasury-note case from Messrs. Alexander Duckham and Co., Limited, Millwall, London, E.

INDUSTRIAL NOTES.

MR. A. M. DUCKHAM has been appointed Deputy Director-General of Munitions Supply at Armament Buildings. Mr. Duckham was for some time previously at the Munitions Inventions Department.

On Friday, the 7th inst., a meeting was held at the Westminster Palace Hotel, London, with a view to consider the question of amalgamating the whole of the trade unions whose members are employed in the iron and steel trades. Mr. C. W. Bowerman, M.P., secretary of the Trades Union Congress, presided. The unions represented were the Iron and Steel Trade Federation; the British Steel-Smelters, Mill-Iron, and Kindred Trades Association; the National Federation of Blastfurnacemen, Ore-Miners, and Kindred Trades; the Tin-Plate Section of the Dock, Wharf, Riverside, and General Workers' Union; the National Amalgamated Union of Enginemen, Firemen, Mechanics, Motormen, and Electrical Workers; and the National Amalgamated Association of Nut and Bolt Makers. It was decided to appoint a committee, consisting of two members of each of the unions represented, to draft a scheme for amalgamation, the committee to be instructed to report to a further conference to be held early next month.

In the course of a speech which he made at the opening last week of a canteen for female night workers at the Beardmore Works, Paisley, Sir William Beardmore stated, on behalf of the firm, as an inducement to these workers, and in order to encourage the greatest possible effort for the production of munitions, that, as from January 1, this year, till the close of the war, a bonus of 10 per cent. will be paid on the total wages earned by each female worker employed continuously in the factory till the end of the war. This bonus, however, will be subject to the female workers keeping regular time, attending to their duties to the satisfaction of the management, and not absenting themselves unless through illness or with the necessary permission. If these conditions are fulfilled—and there is nothing to prevent it—then, at the termination of the war, each will be in possession at the close of their work there of a useful "nest-egg."

This intimation was warmly greeted by the workers present.

We are informed that a mass meeting of the subscribers to the Board of Arbitration and Conciliation for the Manufactured Iron and Steel Trade of the North of England was held at the Co-operative Hall, Consett, on Saturday last, the 8th inst., with a view to sever their connection with the Board, with which they have been identified since its inception forty-five years ago.

There are over 1000 subscribing members to the Board at the Consett Works. The question as to what trade organisation will be joined is to be discussed at a future meeting.

The ascertainment of Messrs. Price, Waterhouse and Co., accountants, was issued by Messrs. J. R. Winpenny and James Cox, the secretaries to the Board of Conciliation for the manufactured steel trade of the North of England, who notify that steel millmen's wages will be advanced during the next quarter by 5 per cent. The ascertained net selling price of steel plates automatically fixes wages on a sliding-scale basis mutually fixed by the Board in 1896. This advance will bring wages to 32½ per cent. above the standard. Never in the history of the Board have wages reached this high-water mark. The highest previous rate was for the last quarter of 1900, when 27½ per cent. was reached.

The National Advisory Committee on War Output has issued the following statement to the trade unions, the members of which are engaged on munition work:

"His Majesty's Government have given earnest attention to the financial position of the country, to the great and increasing demands which will still be made upon its resources to meet the needs of the war, and to the imperative need for economy in all forms of expenditure and consumption, both public and private. They have also had regard to the general advances of wages that have already been given since the beginning of the war, and to the measures already taken to tax or limit the profits of undertakings. His Majesty's Government have come to the conclusion that, in view of the pressing emergency, any further advances of wages (other than advances following automatically from existing agreements) should be strictly confined to the adjustment of local conditions where such adjustments are proved to be necessary."

In this connection we refer our readers to the article we gave in a former issue (see ENGINEERING, vol. c., page 571).

The Inter-State Commission, which has been conducting investigations in Australia with regard to trade generally, and local industries particularly, has made interesting references, in a recent report, to the possibilities of new industries being established in Australia. What entirely new industries may be established, says the report, is a question depending almost wholly on the condition, whether private enterprise, capital, and expert labour are available for the purpose. This, fortunately, has been the case with the iron and steel industry, which promises an expansion in industrial activity exceeding by far anything which may be anticipated from any other source.

The following are given as typical instances in which Australian raw material may be used in connection with new industries:—Copper wire, rod, tubes, and sheets; yarns; the weaving of woollen fabrics from our own raw material; the immense quantities of fats and oils; the by-products of wool-scouring (at present run to waste); improvement of the process of tanning and preparation of leathers, and investigation as to the possibility of obtaining tanning extracts of commercial value from barks other than wattle; the prospects of the profitable production of alkalies from the natural salt deposits of South and Western Australia; the economic production of wood-pulp from the fibre of the forest trees of Australia; the production of alum and potash from the local deposits of alunite, one of which, in the County of Gloucester, New South Wales, is said to be "one of the most remarkable in the world;" the systematic exploration, with the view of the possible discovery of natural petroleum deposits; the manufacture of tin-plate; the possible utilisation of cheap water-power; the local cultivation of the better qualities of tobacco; the local manufacture of margarine, the growing of flax for fibre and linseed; the manufacture of zinc oxide; the cheapening of the cost of sugar for manufacturing purposes.

The Minister for Lands in New South Wales is developing his scheme for the settlement of returned wounded or disabled soldiers on the land, or, at any rate, those soldiers who desire to secure farms. Altogether 1000 farms will be made available throughout the State during the next twelve months. Each man will be able, if necessary, to secure an advance of 100*l.* to develop his holding.

The Comité des Forges de France states that a Central Bureau has been instituted at the French Ministry of Public Works for the distribution of coal to the public services, to the works employed in national defence, to private works, and to households. It has full power to commandeer any supply. A sales office is established in the chief town of each mining district and in each port through which coal imports take place. Any sale carried out by the French mines or by the importers outside the Central Bureau or the sales offices will be adjudged null and void. All the coke produced by the French metallurgical works will be distributed to the consumers by the Central Bureau, who will also establish lists of priority to be followed by the installations producing gas coke. The prices of French coal are to be decided upon by the French Ministry of Public Works on the 1st and 15th of each month, also the prices to be paid the importers for the coal imported. All the coal, both French and imported, required for domestic purposes will be sold at the above prices, plus the cost of transport. A similar measure establishes the cost of coke.

Railway employees in the United States, says the *Railway Master Mechanic*, New York, receive on the average 44 cents out of every dollar of gross earnings of the railways. In other words, practically half of the total gross earnings of the railways is spent in labour. The other half is expended on material and supplies, rentals, taxes, interest, and dividends. Supply dealers and the holders of railway securities, together with the State, come in for but half of all the railways earn. The employee, therefore, stands in quite as important a position as anyone in the business world or anyone of those who are classed as investors.

We read in the *American Machinist* that, according to information received from Russia, Americans know practically nothing of the present-day Russian machine-building industry. Mr. D. G. Baker, with whom our contemporary is acquainted, has just returned to America after a stay of several months in Russia, and brings facts which completely disprove the common idea that Russia is backward in machinery-building and metal manufacture, and is lacking in skilled mechanics. Complete proof of the erroneousness of these opinions is given by the fact that the Russian output of rifles and ammunition per man-hour is equal to the best of the American records. And so highly does Mr. Baker think of Russian mechanics that not only does he believe them to be the equal of Americans, but, given a shop equipment for mass production, and the choice of operating it in either the United States or Russia, he would choose the latter country to-day. The Russian mechanic is skilful, intelligent, willing to learn an operation, and to continue performing it for long periods of time without dissatisfaction; and, since vodka has been suppressed, his number of working hours per week averages fully as high as that worked in the States. Since the opening of the war, there has been a tremendous increase in the size of metal-working plants, particularly those engaged on small arms, rifle and ordnance ammunition. In addition, there has been a great increase in the production of machine-tools.

NORWEGIAN ORDERS FROM AMERICAN YARDS—Tonnage, of course, is in strong demand everywhere at present, but hardly anywhere more so than in Norway. This country places orders in all parts of the globe—China, Holland, and the United States. Some substantial orders have been placed in the latter country, where the yards still seem capable of executing orders within a reasonable time—in eight or nine months—and at prices which, under the present circumstances, are considered reasonable. Among recent Norwegian orders six have gone to Cleveland, six to yards on the East Coast, and one to San Francisco. The steamers ordered from Cleveland yards are of the so-called Frederikstad type, of 3300 tons, and intended for the timber traffic. The boat ordered in San Francisco is of 9000 tons, will have turbines, and be equipped for burning both coal and liquid fuel. The price is understood to be 800,000 dols. Two Norwegian shipping firms have each placed orders for two motor vessels, of 3500 tons, with a Baltimore yard; they will have twin-propellers, and the price is stated to be 200,000 dols. each; the delivery is to take place towards the end of 1916, from September 15 to December 15, a month interval between each.

PERSONAL.—Messrs. A. J. Greenly and Theodore Denison have taken over Messrs. Baldwin and Wills' works, St. Albans-road, Watford, and commenced business as manufacturing electrical and mechanical engineers, under the style of Messrs. Greenly and Denison. They undertake turning, boring, screw-cutting, planing, die-casting, and wood-working.—Mr. J. E. Weyman, M.I. Mech. E., of Pilgrim House, Newcastle-on-Tyne, and Mr. E. F. Hooper, late managing director of the Wear Fuel Works Company, Limited, South Docks, Sunderland, tar and ammonia distillers, have become associated in connection with by-products and chemical engineering.—The Wailes Dove Bitumastic, Limited, of Newcastle-on-Tyne, announce that Sir Thomas Mitchell, C.V.O., who has been connected with the firm since his retirement from Portsmouth Dockyard, where he was manager of the Constructural Department, has now joined the board of directors.—The Electrical Supplies Company, of 233, Tottenham Court-road, London, W., have arranged for Mr. A. G. Ingleby, late of the Admil Electric Company, to take over the control of the engineering department. This company is now representing the following firms in London and the South of England:—The Keighley Electrical Engineering Company, Limited, for direct-current motors and dynamos for capacities up to and including 125 horse-power; and Messrs. Firth and Russell, of Leeds, for alternating-current motors for capacities up to 100 horse-power.

9½-IN. CENTRE PROJECTILE LATHE.

CONSTRUCTED BY THE COLCHESTER LATHE COMPANY, ENGINEERS, HYTHE, COLCHESTER.

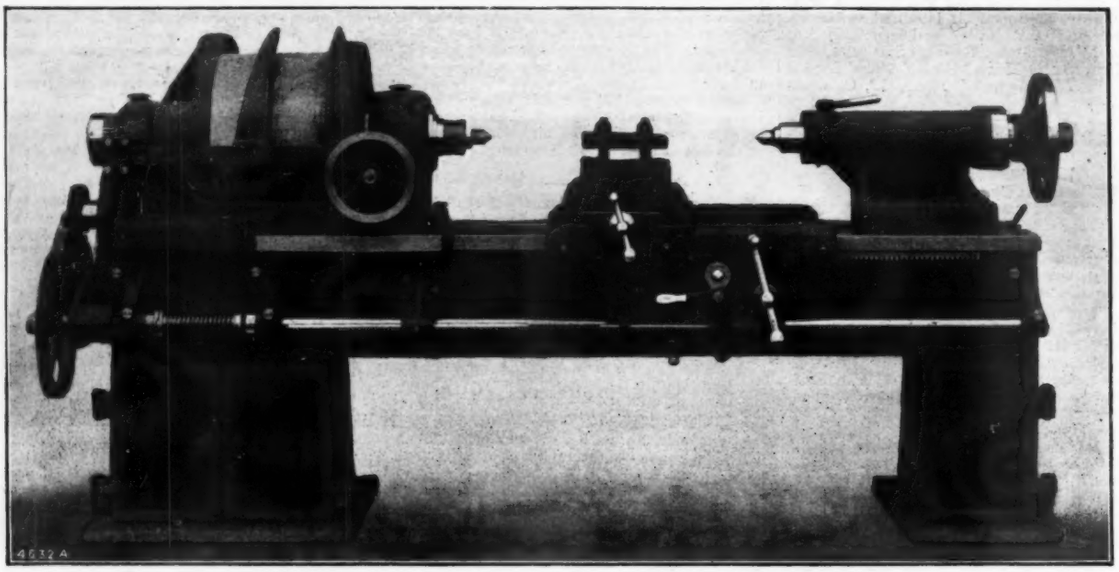
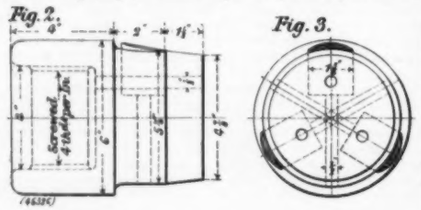
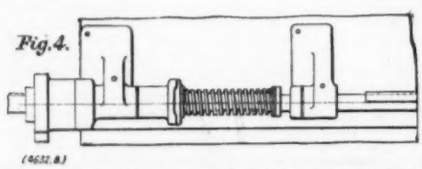


FIG. 1.

WE illustrate above a 9½-in. centre lathe specially designed and constructed by the Colchester Lathe Company, of Hythe, Colchester, for rough-turning projectiles. As will be seen from the photographic illustration, Fig. 1, the tool is of exceptionally simple and massive construction, so that it is quite suitable for operation by semi-skilled labour.

The bed, which is 8 ft. long, 16¼ in. wide, and 12½ in. deep, is carried on two pedestals, which form cupboards for the reception of change-wheels, tools, &c. It is formed with square guides, and is of sufficient strength to withstand the roughest usage. It will have been noticed that the headstock is driven by a pair of fast-and-loose pulleys, so that only one spindle speed is obtainable. This, however, is all that is required, since the tool is only intended for roughing-out shells of one size. The arrangement has the advantage that no countershaft is required, so that first cost is reduced and top light is not obstructed. The headstock pulleys are 18 in. in diameter and are of sufficient width to take a 6-in. belt; a self-contained striking-gear of the rack-and-pinion type, placed in a convenient position for the operator, is clearly visible in Fig. 1. The spindle runs in large adjustable phosphor-bronze bearings, the front one of which is 5 in. in diameter and 7¼ in. long; ball-thrust washers are provided to take the thrust on the spindle. The thrust on the loose headstock, which is also of exceptionally rigid design, is taken by a pawl which engages with a rack fitted on the bed. The provision for thrust is particularly important in this lathe, owing to the form of chuck used. This chuck is illustrated in Figs. 2 and 3. It will be seen to consist of a solid steel body, the front part of which is conical and the intermediate part cylindrical. In the cylindrical part three hardened steel blocks with serrated surfaces are inserted in such a manner that the serrated surfaces form continuations of the smooth conical surface of the front part of the chuck. The base of the hollow shell forging is placed on the chuck and slid along, so that the serrations engage with the edge of the cavity, and the back centre is then brought up to hold the shell in position. This, of course, produces a considerable thrust on the headstocks, but due allowance has been made for this in the design, and the large saving in time effected by the use of this chuck is an advantage which outweighs all other considerations.





The saddle, which has large bearing surfaces and long guides, carries a slide-rest of the plain block type. The gearing under the apron is carried in double bearings, and is actuated by a steel drop-worm engaging with a phosphor-bronze wheel; an automatic knock-off gear, which is distinguishable in Fig. 1, is provided. The feed-shaft is driven by change-wheels through a slipping-clutch, visible in Fig. 1, and separately illustrated in Fig. 4. This acts as a safety device, and prevents the damage which would otherwise occur if an excessively heavy cut were put on, or if the saddle came up against the headstocks owing to the knock-off gear not having been properly set. Altogether the tool seems to be extremely well adapted for heavy work in munition factories with the class of labour now available, and we understand that a large number have been so employed with very satisfactory results.

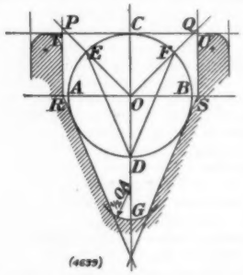
CONTRACTS. — The Manometer Manufacturing Company, Limited, Aston, Birmingham, inform us that they have received orders for complete batteries of their various furnaces for new arsenals.

THE LATE MR. LEWIS GRANT, KIRKCALDY. — We regret to learn of the death, on the 10th inst., at his residence, Lettoch, Kirkcaldy, of Mr. Lewis Grant, head of the well-known engineering firm of Messrs. Douglas and Grant, Dunnikier Foundry, Kirkcaldy. Mr. Grant, who was in his 72nd year, was a son of the manse, his father being the late Rev. William Grant, minister of Cavers, Roxburghshire, but the subject of our memoir was educated in Edinburgh, whither his family had gone on the death of his father. Early in life he showed a natural aptitude for engineering, and was trained in both theory and practice. His firm did a great variety of work, particularly for export trade, and notably in connection with the rice industry in the East; South Africa was also a large field for their enterprise. Some years ago, Mr. Grant made a tour of the world, in order to become more conversant with the requirements of his wide circle of clients. He recognised his duty as a leader of industry, and was connected with several of the local administrative bodies; he was for a number of years chairman of the Kirkcaldy School Board. He was identified too with the Established Church of Scotland, and was connected with, and liberally supported, many of the committees. His two sons are on Army service, one being in the R.A.M.C. in France.

ROPE-GROOVES FOR PULLEYS.

MR. THOMAS HART, of the Lambeth Works, Blackburn, the well-known manufacturer of cotton driving-ropes, has just issued a sheet showing a new form of rope-groove which he considers to have advantages over sections in general use. The groove is made to an angle of 45 deg., but is deeper than usual.

The annexed diagram shows the form and proportions of the groove, the section being laid out as follows:—With centre O and radius O A draw a circle equal in diameter to the rope required. Draw horizontal and vertical diameters A O B and C O D. With A, B, and C as centres, and radius O A, draw arcs to intersect at P and Q. Join P and Q to centre O,



cutting circle at E and F. Join D E and D F, and parallel to these two lines draw tangents to the circle cutting A B, produced at R and S. Through R and S draw R T and S U parallel to C O D, cutting P C Q, produced in T and U. Make D G = D O, and draw arc through G with radius = ½ O A. Thickness of the mid-feathers = ½ O A. Round off all corners of the groove T R G S U.

Owing to the reduction in diameter of driving-ropes which occurs during work, Mr. Hart considers that with some forms of groove now used the ropes soon work too near the bottom, thus causing a tendency to slip. With the form of groove which he is now advocating, Mr. Hart claims that this risk of the rope touching the bottom of the groove is removed.

CANADIAN METALLURGY.—The output of pig-iron in Canada decreased last year 28 per cent.; the average selling price was also slightly lower. Efforts are being made to produce molybdenite, which is in demand in England for the manufacture of steel for ordnance-working tools. The British Government has requisitioned all supplies of this mineral arriving in Great Britain. Molybdenite occurs in pockets in many parts of Eastern Ontario, and it is not expected that there will be much difficulty in obtaining considerable supplies to meet the current requirements.

ELECTRICAL RAILWAYS.*

By HENRY METCALF HOBART, M. Inst. C.E.

(*Continued from page* 24.)

The Frictional Resistance of Electric Locomotives.—For these portions of the journey during which the motors are propelling the train, the losses in friction of gearing and of commutator brushes, the bearing friction of the armature, and the windage friction of the armature and commutator are taken into account in the value of the efficiency of the electrical equipment. But during the times when the train is impelled exclusively by its own momentum or by gravity, these constitute components of the frictional resistance of the locomotive. In careful analyses of train movements it is sometimes of importance to have a full realisation of the extent to which these components may affect the frictional resistance of the locomotive. The losses mentioned will, according to the particular design, usually amount to from 3 to 5 per cent. of the continuous rating of the electrical equipment. Taking 4.0 per cent. for the Butte locomotive, then when two locomotives are employed, as in the runs we have analysed, we have—

$$2 \times 1080 \times 0.040 = 86 \text{ horse-power.}$$

If we denote the corresponding resistance, in pounds per ton, by P, we have for the locomotives' rated speed of 16.2 miles per hour—

$$P = \frac{86 \times 60 \times 33{,}000}{16.2 \times 5280 \times 2 \times 72} = 14 \text{ lb. per ton.}$$

In analysing the run from Rocker to East Anaconda, the resistance for the entire train was taken as 6 lb. per ton. Since for coasting the frictional resistances associated with armatures, commutators, and gears alone amount to 14 lb. per ton, our assumption is only tenable on the basis of a frictional resistance of less than 6 lb. per ton for the loaded ore-cars, and materially more than 6 lb. per ton for the resistance of the locomotives. Let us take the total resistance of the locomotives, when coasting, as 18 lb. per ton. This leaves for the friction of the ore-cars—

$$\frac{6 \times 3700 - 18 \times 144}{3700 - 144} = 5.5 \text{ lb. per ton.}$$

On this assumption the portion of the resistance of the locomotives which is not included in the losses in the electrical equipment is (18 − 14 =) 4 lb. per ton.

"Drivers-to-Draw-Bar" Efficiency during the West-bound Run.—Taking into account these differences between the frictional resistance of locomotives and loaded ore-cars, we have, for the "drivers-to-draw-bar" efficiency—

$$\frac{5.5 \times 3556 \times 100}{5.5 \times 3556 + 4 \times 144} = 97 \text{ per cent.}$$

If the difference between the frictional resistance of the locomotives and loaded ore-cars, in pounds per ton, had not been taken into account, the "drivers-to-draw-bar" efficiency would have been $\left(\frac{3556 \times 100}{3700} = \right)$ 95 per cent., the 1 per cent. difference in this case being of negligible consequence. Any distinction of this sort should, of course, be based upon quantitative measurements, and the example is merely given as suggesting the nature of the required data.

The total efficiency of the locomotive, "from pantograph to draw-bar," is equal to the "efficiency of the electrical equipment" multiplied by the "drivers-to-draw-bar" efficiency. In this case we have—

"Pantograph draw-bar" efficiency = 84 × 0.97
= 81.5 per cent.

On the east-bound journey the locomotives hauled empty ore-cars, whose friction is high. Let us take the friction of the complete train at 10 lb. per ton. The first 8 miles consists of an average 0.20 per cent. down grade. This contributes (0.2 × 22.4 =) 4.5 lb. per ton towards overcoming train friction. The remaining 5.5 lb. per ton must be supplied from the motors. There is consequently required for this 8 miles

$$\frac{5.5 \times 1190 \times 8 \times 5280}{2{,}659{,}000} = 106 \text{ kw.-hours.}$$

For the remaining 12 miles of the journey (*i.e.*, from Gregson to Rocker) the train rises 260 ft., and requires—
For overcoming friction—

$$\frac{10 \times 1190 \times 12 \times 5280}{2{,}659{,}000} = 285 \text{ kw.-hours.}$$

For overcoming gravity—

$$\frac{260 \times 1190 \times 2240}{2{,}659{,}000} = 260 \text{ kw.-hours.}$$

The schedule speed was 20 miles per hour, and the maximum speed was 29 miles per hour. The momentum of the 1170-ton train at 29 miles per hour is 28 kw.-hours. Let us assume that in originally acquiring speed and in accelerating after slow-downs, 60 kw.-hours was absorbed by the train in momentum-energy in the course of the 20-mile journey.

We now have—

	Kilowatt-Hours.
Output from motors from East Anaconda to Gregson..	105
Output from motors for overcoming friction for remaining 12 miles	285
Output from motors for overcoming gravity for remaining 12 miles	260
Output from motors for providing momentum ..	60
Total output from motors for 20-mile journey ..	710

Since the input was 852 kw.-hours, the losses in the electrical equipment were (852 − 710 =) 142 kw.-hours. The efficiency of the electrical equipment for the east-bound journey was thus $\left(\frac{710 \times 100}{852} = \right)$ 83.3 per cent.

The "Drivers-to-Draw-Bar" Efficiency during the East-Bound Run.—Again, taking the friction of the locomotives at 4 lb. per ton, we have—

"Drivers-to-draw-bar" efficiency

$$= \frac{10 \times 1190 - 4 \times 144}{10 \times 1190} \times 100 = 95 \text{ per cent.}$$

Had no distinction been drawn between the different

Fig. 4.

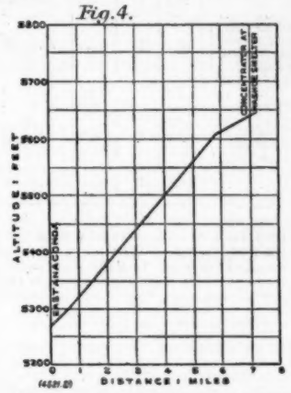


FIG. 4. PROFILE OF THE BUTTE, ANACONDA AND PACIFIC RAILWAY BETWEEN EAST ANACONDA AND THE WASHOE SMELTER.

Fig. 5.

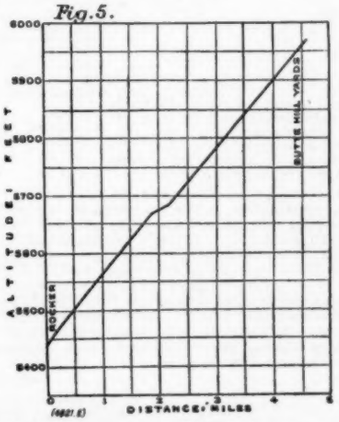


FIG. 5. PROFILE OF THE BUTTE, ANACONDA AND PACIFIC RAILWAY BETWEEN ROCKER AND BUTTE HILL YARDS.

frictional resistances of locomotives and empty ore-cars, the result would have been

"Drivers-to-draw-bar" efficiency

$$= \frac{1190 - 144}{1190} \times 100 = 88 \text{ per cent.}$$

Here is a difference of 7 per cent. as against the difference of only 1 per cent. for the conditions of the west-bound journey with loaded ore-cars. While in the one case the distinction is of importance, in the other case it is practically negligible.

The "pantograph-draw-bar" efficiency for the east-bound trip is

83 3 × 0.95 = 79.2 per cent.

The assumptions made in these calculations are, of course, of so rough a character as simply to indicate the approximate results.

In Figs. 4 and 5 are shown the profiles of the two portions of the system connecting the main line with the Washoe smelter and the Butte Hill mines respectively. The former has a ruling grade of 1.1 per cent. and an average grade of 1.02 per cent. The Washoe smelter is located at an altitude of 380 ft. above East Anaconda, and the distance by rail is 7 miles. The Butte Hill yards are 4.5 miles by rail from Rocker and 520 ft. above it. This 4.5-mile section has a ruling gradient of 2.5 per cent. and an average gradient of 2.2 per cent. The ore-cars are loaded whilst on spur tracks on Butte Hill. After they are loaded, the cars are drawn to the Butte Hill yards and made up into trains of some thirty-five to forty-five cars each.

On the arrival of these trains at Rocker they are usually re-arranged into longer trains, which then travel over the main line to East Anaconda. At East Anaconda the long trains were formerly, when steam locomotives were used, broken up into trains of only sixteen cars each, and each of these short trains was hauled up to the Washoe smelter behind a steam locomotive which required about 45 minutes for the 7-mile journey. When electric operation was first inaugurated, two 72-ton electric locomotives were employed in hauling these same sixteen-car trains. They made the trip in only 22 minutes, *i.e.*, in half the time required by the steam locomotives. At present, however, greater advantage is taken of the larger capacity of the electric locomotives, and they haul twenty-five cars from East Anaconda to the Washoe smelter. The running time is 26 minutes as against the 45 minutes required by the steam locomotive in making the same journey with only sixteen cars. No time is, however, saved in returning with the empty cars, since the curves on this section limit the safe maximum speed to 25 miles per hour.

Test runs have been made on this Smelter Hill service of hauling loaded ore trains from East Anaconda to the concentrator. The following is a record of three runs and their average :—

From..	East Anaconda
To	Concentrator on Smelter Hill
Distance	7 miles
Vertical lift	380 ft.
Friction (assumed)	6 lb. per British ton
Motive power	Two 72-ton locomotives

Designation of Run.	1	2	3	Average.
Number of cars in train	18	21	25	21.3
Gross weight of train in British tons	1,270	1,410	1,710	1,460
Gross ton-miles	8,900	9 900	12,000	10,300
Schedule speed in miles per hour	16.1	16.2	14.2	15.5
Total consumption in kilowatt-hours	580	560	746	629
Watt-hours per ton-mile.. ..	65.1	56.5	62.2	61.5
Kilowatt-hours per train-mile ..	..	..	..	90

Let us endeavour to check the average results in the last column. The train is hauled up this heavy grade at a fairly steady speed, and, corresponding to the schedule speed of 15.5 miles per hour, we may take the maximum speed as being 22 miles per hour. The momentum of a 1460-ton train at 22 miles per hour is

$$\left[1/2 \times \frac{1460 \times 2240}{32.2} \times \left(\frac{22 \times 5280}{3600}\right)^2 = \right] 52{,}460{,}000 \text{ ft.-lb.,}$$

or $\left(\frac{52.4}{2.659} = \right)$ 19.8 kilowatt-hours. The allowance for acceleration from rest and after slow-downs will, in this instance, be assumed to be 40 kilowatt-hours. The energy to overcome friction amounts to

$$\left(\frac{6 \times 1460 \times 7.0 \times 5280}{2{,}659{,}000} = \right) 12.2 \text{ kw.-hours.}$$

The energy to overcome gravity amounts to

$$\left(\frac{380 \times 1460 \times 2240}{2{,}659{,}000} = \right) 470 \text{ kw.-hours.}$$

The output from the motors is

(40 + 12 + 470 =) 522 kw.-hours.

Since the input is 629 kw.-hours, the losses in the electrical equipments are (629 − 522 =) 107 kw.-hours, and the efficiency of the electrical equipments is

$$\left(\frac{522}{629} \times 100 = \right) 83 \text{ per cent.}$$

On the assumption of frictional resistances (except when coasting) of 4 lb. per ton for locomotives, and 5.5 lb. per ton for loaded ore-cars, we have—

"Drivers-to-draw-bar" efficiency

$$= \frac{5.5 \times 1316 \times 100}{5.5 \times 1316 + 4 \times 144} = 92.8 \text{ per cent.}$$

The "pantograph-draw-bar efficiency is

83.0 × 0.928 = 77.0 per cent.

In the estimation of the efficiencies of the electrical equipments for the two runs between Rocker and East Anaconda, and for this run from East Anaconda to the concentrator, rough assumptions of an average frictional resistance for the entire train have been deemed sufficient, the allocation of different values to ore-cars and locomotives merely having been introduced for the "drivers-to-draw-bar" efficiency in order to explain the importance of the distinction, and with a view to suggesting the desirability of measurements permitting of its correct estimation.

In the table on the next page are brought together the three sets of efficiency results.

If a locomotive is loaded up to the limit of the co-efficient of adhesion on the ruling grade—*i.e.*, if, on the ruling grade, it is exerting a tractive effort of some 18 per cent. of the weight on drivers, the "drivers-to-draw-bar" efficiency will be less the steeper the grade. It will also be less the lower the ratio of the weight on drivers to the total weight of the locomotive.

During the journeys up Smelter Hill, the data of which are tabulated above, the average output per motor was

$$\frac{522 \times 15.5}{8 \times 7.0} = 144 \text{ kw.} = 192 \text{ horse-power.}$$

* James Forrest Lecture, delivered before the Institution of Civil Engineers, on Tuesday, December 14, 1915. In the enforced absence of Mr. Hobart in America, this lecture was delivered on his behalf by Mr. John A. F. Aspinall, M. Inst. C.E.

—	Efficiency of Electrical Equipments	"Drivers-to-Draw-Bar" Efficiency.	"Pantograph-Draw-Bar" Efficiency of Locomotives.
	per cent.	per cent.	per cent.
West-bound trip of 3700-ton train of loaded ore-cars from Rocker to East Anaconda at a schedule speed of 20 miles per hour	84.0	97.0	81.5
East-bound trip of 1190-ton train of empty ore-cars from East Anaconda to Rocker at a speed of 20 miles per hour	83.0	95.3	79.2
7-mile trip up Smelter Hill with two 72-ton locomotives hauling 1316 tons of loaded ore-cars, the total train weight being 1460 tons	83.0	92.8	77.0

Since the continuous rating of each motor is

$$\left(\frac{1080}{4} =\right) 270 \text{ horse-power},$$

the average load was 71.3 per cent. of the motor's continuous rating.

The Equivalent Run with Steam Locomotives.

If this 7-mile run up Smelter Hill were required to be made by means of steam locomotives at the schedule speed of 15.5 miles per hour, attained when employing electric locomotives, it would be necessary to employ two steam locomotives, and each, with loaded tender, would weigh, say, 142 tons, thus increasing the total train weight from 1460 to 1600 tons. This would require an average development in the cylinders of about 2200 indicated horse-power. Making no allowance for any stop, the total energy for the 7-mile climb would be

$$\left(\frac{7}{15.5} \times 2200 =\right) 990 \text{ i.h.p. hours.}$$

At 3.7* lb. of coal per indicated horse-power hour the consumption for the journey would amount to 3660 lb. The coal consumption per train-mile would be 520 lb. At 19s. per ton the fuel cost per steam train-mile would be 52d. At an outlay of 0.265d. per kilowatt-hour for electricity, and assuming an over-all efficiency of 75 per cent. from the point of purchase to the pantograph, the power cost per electric train-mile works out at

$$\frac{90}{0.75} \times 0.265 = 32.0\text{d.},$$

or 62 per cent of the outlay for fuel for the steam train.

The fact that the outlay for fuel and power per locomotive-mile has, for the average of all the traffic on the road, decreased to only 39 per cent. as much with electric as with steam locomotives, as shown by the results in the table on page 47, indicates that the coal consumption per indicated horse-power is much in excess of the 3.7 lb. assumed in the above estimate. It is probably more of the order of at least 5 lb. per indicated horse-power hour (61,000 B.Th.U. per indicated-horse-power hour).

Segregation of Locomotives' Activities.

Let us now review the familiar studies of the segregation of the total hours in the life of a locomotive. Mr. L. R. Pomeroy, in a paper entitled "The Electrification of Trunk Lines"† states that from an actual three months' test on a trunk line, a committee on time service of locomotives gave the following as the representative division of a "locomotive working day" for freight locomotives:—

—	Average per Day.	Per Cent. of the 24 Hours.
	hours.	
A. Time for which mechanical department is responsible	5.3	22
B. The average time the locomotive is performing useful work, i.e., actually pulling trains (taken at 3000 miles per month and 100 miles per day) ..	6.7	28
C. Time that the locomotive is under steam, with crew, and ready to go, i.e., time at terminal yards, side tracks, and awaiting orders	12.0	50
Total	24.0	100

In the paper in question Mr. Pomeroy cites this data in seeking to make the point that the only extent to which this state of affairs can be improved by substituting electric locomotives is in reducing A to about one-half, and in, "perhaps owing to greater speed," increasing B, but that C, which he calls "the lost-motion period due to traffic and operating causes," is inevitable. The results already obtained on the Butte, Anaconda and Pacific Railway, however, are to the effect that the "lost-motion" conditions are decidedly improved with electric locomotives. Mr. Pomeroy, in the same paper, quotes Mallets as burning from 600 lb. to 800 lb. of coal per hour while lying on sidings, and states that under these circumstances a "2-8-0 locomotive with 50 sq. ft. of grate surface burns 300 lb. of coal per hour."

Mr. C. P. Kahler, electrical engineer of the Oregon Short Line Railway, in a paper entitled "Trunk Line Electrification,"* publishes tables (from which the following table has been compiled) showing the allocation of time of the twenty-eight passenger and ninety-six freight locomotives employed on a section of a railroad between 500 and 600 miles in length.

—	Passenger Locomotives.			Freight Locomotives.		
	Per Cent. of Total Time.	Days per Year.	Number of Locomotives.	Per Cent. of Total Time.	Days per Year.	Number of Locomotives.
In shops	22.4	82	6.2	28.2	103	27.1
Spare	1.4	5	0.4	2.7	10	2.6
In engine-house (having running repairs done, boilers washed, fire-boxes cleaned) ..	53.2	194	14.9	35.9	131	34.4
Running to and from trains	1.6	6	0.5	1.1	4	1.0
In helper service ..	1.1	4	0.3	4.3	16	4.2
On road—						
Actually running ..	20.3	74	5.7	17.1	62	16.4
Standing on sidings, taking water, &c.				10.7	39	10.3
Totals	100.0	365	28.0	100.0	365	96.0

In this connection Mr. Kahler makes the further statement that "the records of two western steam roads show that their passenger locomotives spent respectively 21 per cent. and 17 per cent. of their time in the shops, and that the freight locomotives of the same roads were in the shop 30 per cent. and 24 per cent. of their time."

Steam-Locomotive Efficiencies.

The following efficiencies have been estimated by the author (in a paper entitled "2400-Volt Railway Electrification," published at page 1149 of vol. xxxii. (1013) of the Transactions of the American Institute of Electrical Engineers), as not likely to be exceeded by steam locomotives in regular service:—

—	Efficiencies.	
	Express Passenger Service.	Heavy Freight Service.
	per cent.	per cent.
From coal to cylinders whilst train is running on its useful journey	5.2	4.6
From coal to rims of drivers	4.4	3.9
From coal to draw-bar	3.5	3.2
Do. corrected for coal burned at other times than on the useful journey	2.7	2.3

In a contribution to the discussion of the paper in question, Mr. Roger Smith gave figures for the "coal-to-draw-bar" and for the "journey" efficiency based upon the Great Western Railway's express passenger service, burning Welsh coal of a calorific value of 15,400 B.Th.U. per lb. The fuel consumption for that service was 2.75 lb. per indicated-horse-power hour (42,500 B.Th.U. per indicated-horse-power hour), and the ratio of draw-bar horse-power to indicated horse-power was taken as 0.70. Mr. Roger Smith's figures and the author's are brought together in the following table:—

—	Over-all Efficiencies for Express Passenger Service with Steam Locomotives.	
	Author's Estimate.	Great Western Railway.
	per cent.	per cent.
From coal to draw-bar	3.5	4.1
Do. corrected for coal burned at other times than on the useful journey	2.7	3.2

In the same paper the author contrasts the efficiencies of the order of 3 per cent. with the actual working efficiencies of over 6 per cent. from the coal in the electricity supply-station to the rims of the drivers on the locomotives, which, with electric propulsion, are obtained not only with dense services of frequently-stopping trains, but also with quite sparse services of trains running considerable distances between stops. By thus more than doubling the over-all efficiency from the fuel to the rims of the drivers, the fuel consumption is, for a given service, decreased to less than half that corresponding to the use of steam locomotives. Furthermore, a much cheaper fuel can be burned in generating-stations than is practicable on locomotives, and it is conservative to set the outlay for fuel for a given traffic at one-third as much in the former case as in the latter.

Steam-Locomotive Coal Consumption per Indicated-Horse-Power Hour.—It is of little use to make statements of the coal consumption of locomotives per indicated-horse-power hour without associating with such statements data of the calorific value of the coal in B.Th.U. per pound (or kilowatt-hour per pound or per ton). While laboratory tests of locomotives may show consumptions as low as 30,000 B.Th.U. per indicated-horse-power hour, it is rare that, taking into account its entire traffic of all kinds, a railway operates with less than 80,000 B.Th.U. per indicated horse-power hour, and figures decidedly in excess of this are common.* When consideration is given to such figures as those already set forth, showing the large amount of time that locomotives are burning fuel whilst not pulling trains, it becomes clear that this must be the case. For specific runs discussed in this paper consumptions of 45,000 B.Th.U. per indicated-horse-power hour are debited against steam locomotives. When compared with the results of laboratory tests at the locomotive's most economical load, such a figure as 45,000 B.Th.U. per indicated-horse-power hour looks high at first glance; but although reliable data of the coal consumption of locomotives in actual service is very meagre, there is no doubt that such values favour the steam locomotive in comparisons of the kind undertaken in this paper.

Coal Consumption in Electricity-Generating Stations.

Recent years have witnessed marked improvement in the over-all efficiency of electricity-generating stations; 13 per cent. from coal pile to outgoing cables represents a typical value for the annual over-all efficiency for large modern stations with a good load-factor, say a load-factor of 0.5. This means that, taken over the entire year, 13 per cent. of the calorific value of the coal burned is sent out of the station as electricity. On the basis of coal of a calorific value of 14,000 B.Th.U. per pound $\left(\text{or } \frac{14{,}000}{3411} = 7.10 \text{ kw.-hours per pound}\right)$, an over-all efficiency of 13 per cent. is obtained when the coal consumption for the entire year works out at $\left(\frac{3411}{14{,}000 \times 0.13} =\right)$ 1.9 lb. per kilowatt-hour of output from the generating-station.

Influence of Greater Speed and Heavier Trains on Outlay for Engine Crews and Train Crews.

Whereas in the days of "all-steam locomotive" operation of the Butte, Anaconda and Pacific Railroad the average weight of the ore trains was 1600 British tons, the average weight with electric locomotives has been increased 34 per cent., to 2100 British tons. For hauling a given quantity of ore, this has permitted of decreasing the number of trains per day by 25 per cent. Furthermore, the running time on the various sections has been greatly decreased, and delays have been largely eliminated as compared with the conditions formerly obtaining with steam locomotives.

The consequences of the improvements in these respects are very marked as regards decreased outlay for wages of enginemen and train crews. As regards the engine crews the improvement is strikingly shown in the following table:—

—	Number of Hours Engine Crews were Employed in Various Services.		
	Regular Hours.	Overtime Hours.	Total Hours.
Month of June, 1913, when operation was with 27 steam locomotives	4230	1010	5290
Month of June, 1914, when operation was with four steam locomotives and 17 electric locomotives	3300	440	3740
Decrease in June, 1914, as compared with June, 1913	930	570	1550
Do. in per cent.	23 per cent.	56 per cent.	29 per cent.
Inferred percentage decrease with "all-electric" service	25 per cent.	65 per cent.	33 per cent.

Only a single engine crew is employed even when a train is headed by two 72-ton electric locomotives, since the control is effected entirely in the leading locomotive. Although the scale of wages paid by the Butte, Anaconda and Pacific Railway is the same as formerly with "all-steam-locomotive" operation, the total expenditure for wages of enginemen has decreased from 21,000*l.* per annum with "all-steam-locomotive" operation (or 780*l.* per locomotive) to 14,000*l.* per annum at present with four steam and seventeen electric locomotives. Of this latter figure of 14,000*l.* per annum, 5000*l.* per annum is due to the four steam locomotives (or 1250*l.* per locomotive), and 9000*l.* to the seventeen electric locomotives (or 530*l.* per locomotive), although the average mileage per electric locomotive is 41,000 miles per annum against an average of only 32,500 miles per annum for each of the four steam locomotives. The outlay for engine crews per locomotive-mile is shown in the table on the next page.

* 3.7 lb. of coal (of a calorific value of 12,250 B.Th.U. per lb.) per indicated horse-power is 45,500 B.Th.U. per indicated horse-power hour, or $\left(\frac{45{,}500}{3411} =\right)$ 13.3 kilowatt-hours per indicated horse-power hour. The corresponding efficiency from the fuel to the cylinder is $\left(\frac{0.746}{13.3} =\right)$ 5.6 per cent.

† Proceedings of the Institution of Mechanical Engineers, 1910, page 1195.

* Transactions of the American Institute of Electrical Engineers, vol. xxxii. (1913), page 1205.

* At page 1034 of vol. xvii. (1914) of the *General Electric Review*, Mr. A. H. Armstrong writes:—"Carefully compiled statistics indicate that certain western railroads purchase in the neighbourhood of 12 lb. of coal for each horse-power hour of actual work expended at the driver rims in hauling trains of all classes." The fuel was of 11,000 B.Th.U. quality; consequently, the gross consumption amounted to 132,000 B.Th.U. per horse-power hour at the rims of the drivers.

—		Expenditure for Wages of Engine Crews per Locomotive-Mile.
		d.
Prior to the summer of 1913 when employing twenty-seven steam locomotives		6.6
At present with four steam locomotives and seventeen electric locomotives	Per steam locomotive-mile	7.2
	Per electric locomotive-mile	3.2

A related saving which should be credited to electric operation is that of 6200*l.* per annum in trainmen's wages, a decrease of 21 per cent. This decrease is mainly accomplished by the greater speed, less delays, and consequent great reduction in overtime. Although this decrease in outlay for trainmen's wages is not a component of locomotive expenditures, it has been effected through improvement in locomotive performance, and from this viewpoint it is interesting to note that it works out at a saving of 1.7d. per locomotive-mile.

The Passenger Service on the Butte, Anaconda and Pacific Railway.

The passenger service consists of main-line trains between Butte and Anaconda, a distance of 26 miles.* Although with a 72-ton electric locomotive the schedule speed could have been increased 25 per cent., to 32.5 miles per hour, the speed of the passenger train is maintained at only 26 miles per hour, as formerly with steam locomotives. The 72-ton electric locomotives, with their entire weight on drivers, have replaced steam locomotives which weighed, with loaded tender, 118 tons, of which only 54 tons was on drivers. The usual composition of the train now comprises a 72-ton electric locomotive hauling a mail and baggage-coach weighing 36 tons and two passenger coaches each weighing 40 tons. This makes a total train weight of $(72 + 36 + 2 \times 40 =)$ 188 tons. The equivalent train hauled by a steam locomotive weighed 234 tons, or 25 per cent. more than the electric train, the increase of 46 tons in weight being due to the greater weight of steam locomotive and tender.

"Drivers-to-Draw-bar" Efficiencies of Passenger Trains.—Neglecting any differences in the frictional resistances, in pounds per ton, in the locomotive and the load behind the draw-bar, the "drivers-to-draw-bar" efficiencies are—

$$\text{For electric train: } \frac{116}{188} \times 100 = 61.5 \text{ per cent.}$$

$$\text{For steam train: } \frac{116}{234} \times 100 = 49.5 \text{ per cent.}$$

Whereas during June, 1913, with steam locomotives, the total passenger-train delays amounted to 1250 minutes, the delays for June, 1914, with electric locomotives, amounted to only 310 minutes, or only one-fourth as much as with steam.

Locomotive Expenditure per Locomotive-Mile.

It will be seen that for so miscellaneous a traffic as that on the Butte, Anaconda and Pacific Railway analyses of the component sorts of traffic are practically out of the question. The locomotive expenditures per locomotive-mile during the last six months of "all-steam-locomotive" operation are compared with those during the corresponding six months of the following year, when four steam locomotives and seventeen electric locomotives were used, in the following table:—

—	—	Locomotive Expenditure per Locomotive-Mile.		
		"All-Steam Locomotives" Operation	Operation with Four Steam Locomotives and Seventeen Electric Locomotives.	
		Pence per Steam Locomotive-Mile.	Pence per Steam Locomotive-Mile.	Pence per Electric Locomotive-Mile.
I. Maintenance of equipment expenses.	Repairs	6.5	8.6	2.2
	Depreciation*	1.0	2.1	1.2
	Supervision	0.4	0.8	0.2
	Total	7.9	11.5	3.6
II. Transportation expenses.	Wages of engine-men	6.6	7.2	3.2
	Engine-house expenses	1.9	1.8	0.9
	Fuel and power	19.9	18.1†	7.0
	Water	0.3	0.3	—
	Lubrication	0.6	0.7	0.2
	Other supplies	0.3	0.6	0.2
	Total	29.6	28.7	11.5
Total (I.) plus Total (II.)		37.5	40.2	15.1

* The amount to be set against depreciation is more or less arbitrarily fixed by the Interstate Commerce Commission, and does not necessarily reflect the physical condition of the locomotive.

† The discrepancy between this figure and the 19.5d. given elsewhere in this paper is due to fluctuations in the average price of coal. On page 46 the same price (19s. per ton) was taken for both periods.

With the traffic of some 800,000 locomotive-miles per annum, which may be taken as roughly representative of the usual conditions on the Butte, Anaconda and Pacific Railway, the two items of expenditure, of which the locomotive-mile costs are given in the preceding table, would make up annual outlays of—

$$\left(\frac{37.5 \times 800{,}000}{240} =\right) 125{,}000\text{l.} \text{ for "all-steam locomotive" operation,}$$

and

$$\left(\frac{15.1 \times 800{,}000}{240} =\right) 51{,}000\text{l.} \text{ for "all-electric" operation.}$$

The annual saving under the heading of "Locomotive Expenditure" would thus be—

$$(125{,}000\text{l.} - 51{,}000\text{l.} =) 74{,}000\text{l.}$$

There is involved a further annual saving of some 6000*l.* in outlays for wages of train crews.

As debit items we have repairs and maintenance of substations and distribution system, and the associated wages and supervision items. No statement of these outlays is available. They may fairly be taken as not exceeding 6000*l.* per annum.

Thus the net annual credit available for liquidating the capital expenditure associated with the electrification of the road is—

$$74{,}000\text{l.} + 6000\text{l.} - 6000\text{l.} = 74{,}000\text{l.}$$

The original cost of the electrification of the Butte, Anaconda and Pacific Railway, set forth as required of the railway company by the Interstate Commerce Commission, is shown in the following table:—

Fig. 6.

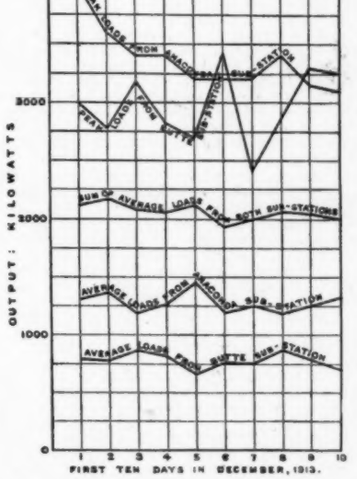


FIG. 6. BUTTE, ANACONDA AND PACIFIC RAILWAY: PEAK AND AVERAGE LOADS FROM SUB-STATIONS.

Designating Number of Account.	Description of Account.	Amount of Account.
		£
1	Engineering and superintendence (including general preliminary report)	2,190
12	Roadway tools (used for construction 19 and 22)	770
16	Crossings, fences, guards, and signs	50
17	Interlocking and signal apparatus. (The introduction of electric operation required the installation of a new system)	4,450
19	Poles and fixtures (approximately 91 miles of track)	27,100
22	Distribution (approximately 91 miles of track were wired)	71,500
25	Sub-station building (existing buildings were used)	40
31 and 36	Electrical equipment (five 1000-kw. motor generator-sets and seventeen 72-ton locomotives)	134,900
41	Interest	2,000
	Total	242,300

The completion of the electrification of the entire 114 miles of single track and the outlay for the four additional locomotives may be roughly taken as increasing this capital expenditure to 300,000*l.* The credit of 74,000*l.* per year, at which we arrived above, is 24.7 per cent. of this total capital expenditure. Furthermore, the additional equipment is being provided to enable the railway to transport 20 per cent. more ore to the Washoe smelter. Consequently, the traffic will henceforth amount to nearly one million locomotive-miles per annum, and the revenue will be proportionately greater. It is thus undoubtedly conservative to state that the savings, as compared with steam locomotive operation, will within seven years of the inauguration of electric operation—*i.e.*, by the year 1920—have liquidated the capital expenditure of 300,000*l.* incurred in the years 1913, 1914, and 1915.

Relative Investment Costs of Electric and Steam Locomotives.

The largest item in the capital expenditure for electrifying a railway of this character is that for electric locomotives. In considering the relative status of steam and electric locomotives, sight must not be lost of the circumstance that for every electric locomotive in existence the number of steam locomotives runs into the hundreds. In the manufacture of steam locomotives the experience of many years is available. Standardised parts are employed throughout. The market price of steam locomotives is of the order of only 30*l.* per British ton, while the corresponding figure for electric locomotives of types in which the axles are driven through gears is usually of the order of 80*l.* to 90*l.* per British ton. While the price of the Butte locomotives has not been published, it would appear from the above assumption that $(72 \times 80 =)$ 5760*l.*, or, say, 6000*l.* per locomotive, should be a representative figure. The capital expenditure for the seventeen original electric locomotives would thus amount to $(17 \times 6000 =)$ 102,000*l.* If we assume for the four additional electric locomotives (including tractor-trucks) a price of 8000*l.* each, we arrive, for the twenty-one electric locomotives, at a total outlay of 134,000*l.* These twenty-one electric locomotives will handle a 20 per cent. greater traffic than the displaced twenty-seven steam locomotives. We may conservatively consider the twenty-one electric locomotives as equivalent (with respect to their capacity to handle the traffic) to thirty-two steam locomotives, with an average weight including tender, of 140 tons and an average cost of $(30 \times 140 =)$ 4200*l.* apiece. Thus the outlay for these thirty-two steam locomotives would be $(32 \times 4200 =)$ 134,000*l.* With the particular price basis selected, this gives us the same total outlay for locomotives, whether steam or electric, and it may in general be said that the greater weight usually required per locomotive and the greater number of locomotives necessary to handle a given amount of traffic, will necessitate as great a total outlay for steam locomotives, notwithstanding their much lower cost per ton, as is required for their equivalent in electric locomotives. With the gradual increase in the number of electric locomotives built and used annually, greater standardisation can be introduced into their manufacture, and their cost per ton will exceed the corresponding value for steam locomotives. However, their construction inherently involves a considerably greater cost per ton than is involved in steam locomotives, but the ratio of costs is, with greater standardisation and the building of thousands annually, in place of dozens, certain to decrease.

The item of "repairs"* of steam locomotives is inherently much greater per mile than that for electric locomotives of approved types. The sixteen "1913" type New York Central electric locomotives of 2600 horse-power continuous capacity (a tractive effort of 13,800 lb. at 54.5 miles per hour), and weighing 119 British tons, require only 1.7d. per locomotive-mile for "repairs," as against 2.9d. for all the steam locomotives on the New York Central Railroad. The electric locomotives on that road average about 26,500 miles per year, as against 38,400 miles for the steam passenger-locomotives and 21,000 miles for the steam freight-locomotives. The reason for the lower annual mileage of the electric locomotives on this road is that they are only employed on the short runs from the Grand Central Station to the 34-miles† distant-limit (Croton) of the electrified zone, whereas the steam passenger-locomotives operate over divisions of not less than 100 miles each. The electric locomotives of the Butte, Anaconda and Pacific Railway require 2.2d. for "repairs" (see the table on this page) per locomotive-mile, as against 6.5d. for the displaced steam locomotives.

The 140-British-ton direct-current locomotives, with a continuous rating of 1800 horse-power (tractive effort 12,300 lb. at 54.3 miles per hour), of which thirty-three have been in operation on the Pennsylvania Railway since 1910 (and which have averaged 28,000 miles per locomotive per year), require for repairs 2.8d. per locomotive-mile, as against 4.2d. for the steam locomotives on the New Jersey Division of the Pennsylvania Railway, and 5.7d. for the average of all the steam locomotives on the entire Pennsylvania Railway, the average miles per year for the steam locomotives being about the same figure as that given above for the electric locomotives on this railway.

Sub-Station Machinery of the Butte, Anaconda and Pacific Railway.

Electrification requires expenditure for sub-station machinery. In the case of the Butte, Anaconda and Pacific Railway it sufficed to locate the sub-station machinery at two points. These locations were respectively on Butte Hill and Smelter Hill, in buildings already serving to house electrical machinery employed at the mines and the smelter. The distance between the two sub-stations is about 26 miles. This relatively great distance apart is rendered practicable by the use of the 2400-volt system for supplying the locomotives. Had it been necessary to keep the pressure down to 600 volts, at least half-a-dozen sub-stations would have been necessary.

* Referring to Fig. 3, it should be stated that Butte lies 4 miles east of Rocker, and that Anaconda lies 2 miles west of East Anaconda.

* "Repairs" should not be confused with maintenance, of which it is only one component, the other components consisting of "depreciation" and "supervision." The last item, namely, "supervision," is usually of the order of one-tenth, or less, of the outlay for "repairs" (see the table on this page).

† The total electrified mileage of single track on the New York Central Railroad is 251 miles.

and then not only would their aggregate initial cost have been at least twice as great as for the two 2400-volt installations, but they would have had a much lower load-factor and a lower "energy" efficiency. Furthermore, a greater outlay would have been required for the wages of sub-station attendants. The sub-station machinery comprises five 720-revolutions-per-minute motor-generator sets, each having a continuous rating of 1000 kw. at 2400 volts when supplied with three-phase, 60-cycle, 2300-volt electricity. Their two-hour rating is 1500 kw., and their five-minute rating 3000 kw. The design comprises a ten-pole synchronous motor direct connected to two four-pole commutating generators. Each of these generators supplies a pressure of 1200 volts at its commutator. The two commutators are connected in series, thus providing the required terminal pressure of 2400 volts. The commutating generators are compound wound, and their pole-shoes are fitted with distributed compensating windings, which, in conjunction with the interpole windings, provide for excellent commutation. The main field-windings are separately excited from a 125-volt supply. There are three of these sets at the Smelter Hill sub-station and two at the Butte Hill sub-station. The entire outlay for sub-station machinery has been only a matter of some 30,000*l.* The precise figure is not published. Each motor-generator set weighs about 36 British tons.

In Fig. 6 are given curves showing for the first ten days in December, 1913, the peak loads and the average loads from the two sub-stations, and the sum of the average loads from the two sub-stations. An examination of this data shows the average load-factor for this period to have been 0.34. The average load for the ten days was 2050 kw., and the peaks for the ten days averaged $\left(\frac{2050}{0.34} =\right)$ 6000 kw.

The motors of the motor-generator sets are proportioned to absorb 1450 kv.a. when the sets are delivering 1000 kw. This is in order that they may be worked with such over-excitation of the motor-fields as to have a leading power-factor. This leading power-factor offsets the lagging power-factor of other customers of the Great Falls Power Company, which supplies the electricity to the railway company. If the sets were worked with a leading power-factor of 0.7, every 1000 kw. consumed would be accompanied by a wattless leading component of 1000 kv.a. This should be of advantage to the supply company, and ought to be worth to them a matter of, say, 0.040d. for every leading kilovolt-ampere-hour. In other words, were the load of unity power-factor, it would, on this assumption, have been consistent to charge the railway company some (0.265 + 0.040 =) 0.305d. per kw.-hour, a 15 per cent. higher price. Conversely, another customer using annually an equal amount of electricity at the same load-factor, but with a lagging power-factor of 0.7, would, if the economics of the business were appreciated, have to pay some (0.305 + 0.040 =) 0.345d.* per kw.-hour, a 30 per cent. higher price than that paid for 0.7 leading power-factor electricity. As a matter of fact, the sub-stations are not operated with a leading power-factor much below unity.

The distribution from the sub-stations has involved the installation of about 250 British tons of copper for feeders. The feeder cables are carried on the trolley-line poles. About 190 tons out of the total feeder copper consists in two cables, each having a cross-section of 0.390 sq. in. These two cables are operated in multiple and extend 26 miles from the Smelter Hill sub-station to the Butte Hill sub-station. They are tapped to the trolley-wire about every 1000 ft. There are further feeders to provide the necessary reinforcement at other portions of the system. In addition to the positive feeder system, which accounts for about 200 tons of copper, the track return-circuits are reinforced with about 50 tons of negative feeders. They comprise over 30 miles of 4/0 (0.166 sq. in.) cable. These negative feeders are also carried on the trolley-line poles. The positive and negative feeder copper, on the basis of 80*l.* per British ton, has involved an outlay of about 20,000*l.*, or an average of $\left(\frac{20,000}{114} =\right)$ 175*l.* per mile of single track. The trolley-conductor has a cross-section of 0.166 sq. in. (4/0 B and S). A conductor of this cross-section weighs 3400 lb. per mile. There has thus been required for the 114 miles of single track 182 tons. At 80*l.* per ton this represents an expenditure of 14,500*l.*, or 127*l.* per mile. The track-rail is chiefly 85 lb. per yard, and about 40,000 bonds have been employed in fitting the 114 miles of single track for electric operation. At 3.3d. per bond the outlay for bonds amounts to 550*l.*, or 4*l.* per mile of single track.

The various items in the cost of the distribution system are brought together in the following table:—

	Per Mile. £
Feeder copper	200
Trolley wire	130
Line material	65
Poles	60
Steel strands	60
Bonds	45
Cost of erection	550
Total cost	1110

* Arno, as the results of an analysis of the influence of lagging power-factors on the cost, arrived at the conclusion that the equitable cost for any power-factor could be estimated by adding one-third of the output in kilovolt-ampere hours to two-thirds of the output in kilowatt-hours. Applying Arno's rule to the above case, then, if 0.305d. is an equitable price per kilowatt-hour for unity-power-factor electricity, the corresponding price for lagging 0.7-power-factor electricity would be (0.33 × 1.41 + 0.67) × 0.305 = 0.347d.

The complete cost of the distribution system, including feeders and bonding, has amounted to 1110*l.* per mile of single track. The maintenance of the entire distribution system, including track-bonding, is running at about 22*l.* per mile of single track.

(To be continued.)

COLONIAL AND FOREIGN ENGINEERING PROJECTS.

WE give below a few data on several colonial and foreign engineering projects, taken from the *Board of Trade Journal*. Further information on these projects can be obtained from the Commercial Intelligence Branch, Board of Trade, 73, Basinghall-street, London, E.C.

Australia: H.M. Trade Commissioner in Australia has forwarded specifications and drawings in connection with a call for tenders by the Commissioner, Queensland Government Railways, Brisbane, for the supply of superstructure of four 60-ft. and four 24-ft. rolled girder-spans for bridge over Salt Water River, Townsville-Ingham Railway. Copies of the specification, form of tender, &c., may be obtained at the office of the Commissioner. Sealed tenders, on the proper forms, will be received up to noon on January 31, at the office of the Agent-General for Queensland, 409, West Strand, London, W.C., where also copies of the specification, &c., may be inspected. Tenders must be accompanied by a preliminary deposit, either in cash or a marked cheque, equal to 1 per cent. of the amount of the tender.

Spain: The *Gaceta de Madrid* of December 24 notifies that tenders will be received, within a period of thirty days from that date, at the Casa Consistorial, Valencia, for the completion of hospital construction works in that city. The estimated cost of the works is 67,657 pesetas (about 2700*l.*). Although this contract will probably be awarded to a Spanish firm, nevertheless the carrying out of the works may involve the purchase of some materials outside Spain. The same issue of the *Gaceta* publishes a Royal Decree authorising the Ministerio de Fomento to make arrangements for the execution of works in connection with the Valbornedo drainage scheme, at an estimated cost of 419,663 pesetas (about 16,780*l.*). Tenders will be invited for the supply of cement, metals, and other necessary materials.

Morocco (French Zone): H.M. Agent and Consul-General at Tangier has forwarded a copy of the Cherifian *Bulletin Officiel*, containing a Decree, dated November 6, 1915, authorising the commencement of, and the expenditure of certain approximate sums on, various public works in the French Zone in Morocco. In some cases these works have already been completed, whilst others are in the course of construction or contracted for, the present Decree having as part object the regularising of anticipatory work undertaken by the Resident-General. The *Bulletin* also contains a report by the French Minister of Foreign Affairs on the works. Out of the total sum of 98,111,424 francs to be expended on these public works, 44,110,000 francs are for the Casablanca harbour works, and 31,520,000 francs are for roads; 6,591,880 francs are assigned as subventions to the municipalities of various towns for public works; 5,357,531 francs for schools, hospitals, &c.; 3,693,467 francs for telegraph and telephone services; 3,225,000 francs for forests, irrigation, drainage, &c.; 1,938,782 francs for public offices, &c.; 700,000 francs for land surveys and maps; 500,000 francs for the preparatory surveys and plans of the Tangier-Fez and other railways; and 474,762 francs for the preservation of historical monuments.

Colombia: The *Diario Oficial*, Bogotà, publishes a Law authorising the Colombian Government to make arrangements for improvement works at Tumaco (State of Cauca) so that the port will be able to accommodate steamships of large draught. When the plans and specifications relative to the work have been approved, public tenders for the execution of the contracts will be invited both in the Republic and abroad. The *Diario* also contains the text of a Law authorising the Government to proceed, either by administration or by contract, to reconstruct the section of the Pacific Railway between the port of Buenaventura and the station of San José a distance of some 37 km. (about 23 miles). These works will not include those which the Pacific Railway Company is under obligation to undertake by the terms of Article 11 of the contract entered into with the Colombian Government on January 23, 1908.

Venezuela: According to the *Gaceta Oficial*, Caracas, tenders were invited by the Venezuelan Ministry of Finance up to December 18, 1915, for the leasing of salt-lands in the Republic for the year 1916. The minimum price fixed for the lease is 4,000,000 bolivars (160,000*l.*). The concessionaire will be allowed to import free of Customs duty machinery, sacks, pack-thread, and all other materials destined exclusively for the working of the salt deposits.

Argentina: The *Boletin Oficial*, Buenos Aires, publishes the text of a memorandum, submitted to the Argentine Ministry of Public Works by the Directorate of the National Sanitation Works Department, showing the position of the works being carried out under the Buenos Aires Sanitation Scheme, from which statement the following particulars have been translated:—The project for the sanitation of the Federal capital, authorised by Law No. 6385, provided for the execution of all the water supply and sewerage works in the Municipality outside the Bastemann Radius, as well as the extension and improvement of those within that area. The estimated cost of the works in the New Radius amounts to 158,332,939 pesos currency, and those in the Old Radius to 10,870,000 pesos. The execution of the works began in 1910, under a plan which developed partially, but by later legislation a new plan was approved, fixing the approximate amounts to be spent each year as follows:—44,000,000 pesos in 1914; 41,000,000 pesos in 1915; 30,000,000 pesos in 1916; and 14,000,000 pesos in 1917. New works were continually being contracted for right up to June, 1914, but the financial situation brought about by the effect of the European War rendered it necessary to reduce in every possible way the activity displayed. Consequently the works at the end of 1916 would not be so far forward as had originally been planned. Nevertheless, the vast scheme has progressed to such an extent that a large area of the Municipality has already derived immense benefits from it. The water supply works:—The water-tower and supply-tunnel and most of the equipment of the Palermo Station are already in full working order. Eight of the twelve pumping-lines which comprise the general plan have now been completed; the large reservoir at Caballito is in use, and another at Villa Devoto is nearly finished. It was anticipated that by the end of 1915 the new works would be distributed over an area of 7175 hectares (about 17,700 acres). The drainage works: The execution of the principal works of the drainage scheme is also in a forward state. Of the 45,000 metres over which the new main sewer will extend, 26,167 metres are already constructed and in working order. Most of the large branches of the main sewer are now finished, and only the minor works of the scheme, such as the street canalisation works, remain to be undertaken. The improvement and extension works in the Old Radius have also made great progress. The two large pumping-tubes are completed, and the old distributing-pipes have been renewed over about 50 per cent. of the area. Of the total sum of the approved estimates of all the works, amounting to 169,202,939 pesos, the sum of 105,204,403 pesos had been spent up to September 30 last. The amount assigned for the October-December quarter would bring this figure to 111,504,774 pesos, thus leaving 57,698,165 pesos for the complete realisation of the existing general scheme. As regards the contemplated works for 1916, the Directorate points out that to stop the works contracted for, or to rescind contracts, which to-day, more than ever, are beneficial to the State, would be disastrous, although the materials and machinery to be acquired from Europe would mean an increase of 30 or 40 per cent. on the original contract prices. The plan of the works for 1916 was approved by a Presidential Decree of October 28 last, and represented an expenditure of 25,891,818 pesos currency, as shown in the following table:—

	For Payment in London. £	For Payment in Buenos Aires Pesos currency
Palermo Station—Power-plant, equipment and general works ..	45,000	3,200,000
Reservoirs at Caballito and Villa Devoto	95,000	1,100,000
Main and distribution pipes ..	—	6,000,000
Main sewer and branches	100,000	5,300,000
Wilde Station—Building and machinery	50,000	100,000
General canalisation	—	5,000,000
Miscellaneous works	—	1,870,000
	290,000	22,570,000
Equivalent of the 290,000*l.* ..		3,321,818
Total in pesos currency ..		25,891,818

Peso currency = 1s. 9d. (about).

The *Boletin Oficial*, Buenos Aires, publishes a Decree approving, with certain modifications, the project prepared by the Department of Public Works of the Province of San Luis relative to works on the Rio Chuscha, to be undertaken in order to prevent further inundations of that river in the Department of Cafayate. The Argentine Irrigation Department will proceed to carry out the necessary works by administration, a sum of 50,000 pesos currency (about 4400*l.*) being assigned for this purpose.

ALEXANDRIA.—The traffic handled at Alexandria (Gabbary station) during the eight years ended with 1914 was as annexed:—1907, 2,493,140 tons; 1908, 2,446,260 tons; 1909, 2,195,609 tons; 1910, 2,219,807 tons; 1911, 2,524,137 tons; 1912, 2,821,601 tons; 1913, 2,568,887 tons; 1914, 2,057,513 tons. The outbreak of the great war in the second half of 1914 affected, of course, the traffic movement of that year, but business was also restricted by the late arrival of cotton and cotton seed from the interior. It will be seen that 1912 was the best of the years under review. The value of the cotton seed exported from Alexandria in 1914 was £E2,298,591, as compared with £E3,294,144 in 1913, and £E4,085,822 in 1912. The value of the cotton exported from Alexandria in 1914 was £E18,669,448, the corresponding totals for 1913 having been £E25,512,293, and for 1912, £E27,528,507. Deliveries to the United Kingdom in 1914 figured for £E7,581,458, as compared with £E10,995,774 in 1913, and £E12,571,438 in 1912. The value of the agricultural machinery imported into Alexandria in 1914 was £E302,635, as compared with £E246,861 in 1913, and £E166,575 in 1912. Electrical machinery (including gas and petrol-driven engines) was also imported into Alexandria in 1914 to the value of £E153,328; the corresponding value in 1913 was £E50,793, and in 1912, £E168,365. The aggregate value of the exports from Alexandria in 1914 was £E23,117,486, as compared with £E30,894,797 in 1913, and £E33,790,256 in 1912. The exports to the United Kingdom and other British Possessions figured in these totals for £E10,129,614 in 1914, £E13,539,940 in 1913, and £E15,857,548 in 1912. Rolling-stock for railways and tramways and tenders for locomotives were imported in 1914 to the value of £E91,204, as compared with £E41,949 in 1913, and £E98,557 in 1912. Steam-engines were also imported in 1914 to the value of £E92,380, as compared with £E134,447 in 1913, and £E87,527 in 1912.